...tion & Use of Materials, Compon... & Finishes in Engineering Design

Engineering Materials and Design

...YWOOD PUBLICATION

OCTOBER 19...

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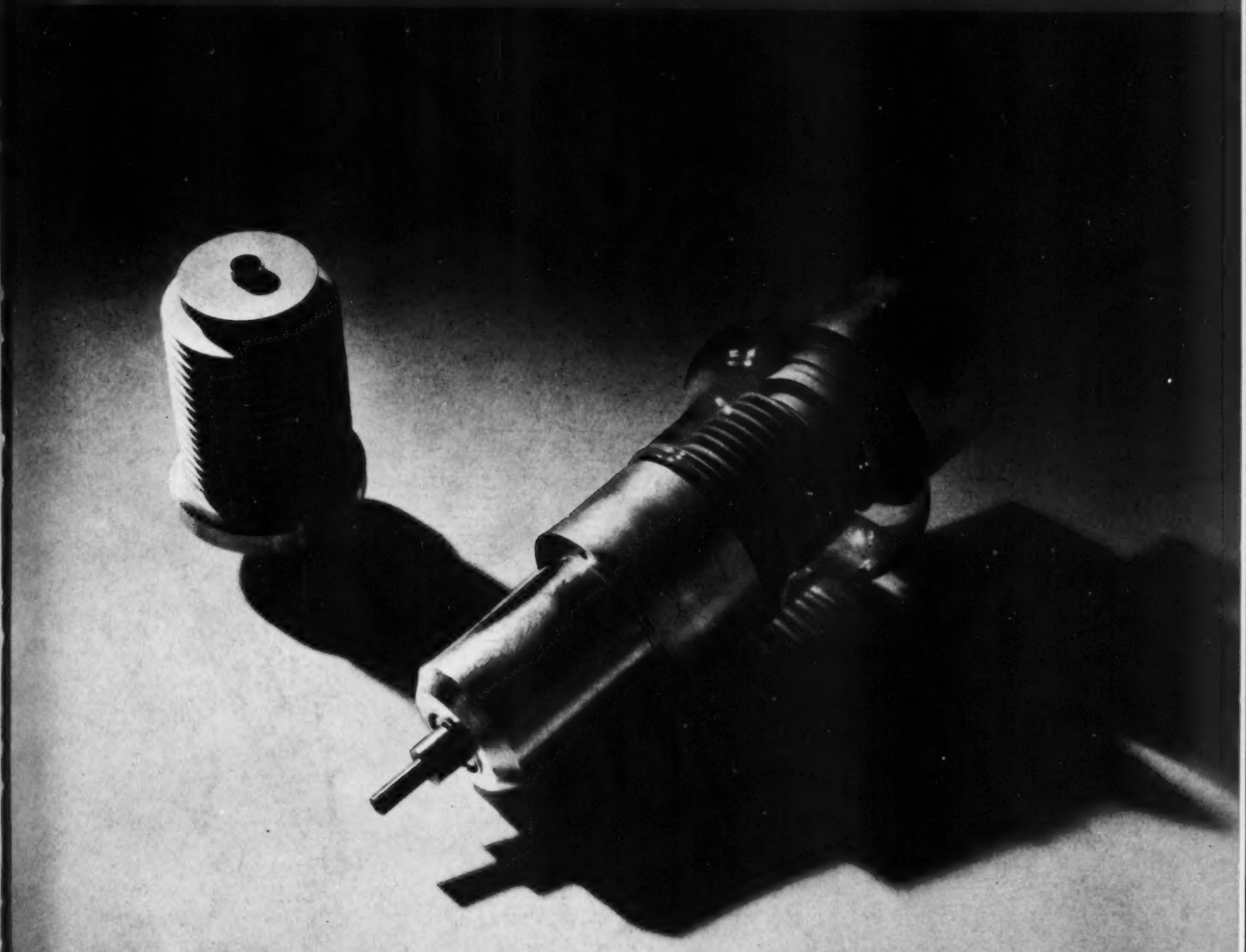

Seamless Metallic Bellows

page 618

EMD 3660 for further information

A New Tool Steel

OSBORN MUSHET SPECIAL 'V.G.' – SPEED STEEL

Mushet Special " VG " high-speed steel is the very latest development of tool steels in the United Kingdom, by Samuel Osborn & Co., Limited. Remarkable results under production conditions are assured, far in advance of other tool steels in this category.
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★ **LAST LONGER**
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● *ALSO AVAILABLE IN BAR AND BLANK FORM*

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Engineering Materials and Design

★ *The Magazine for Engineering Designers*

A HEYWOOD PUBLICATION

Vol. 3 No. 10 October 1960

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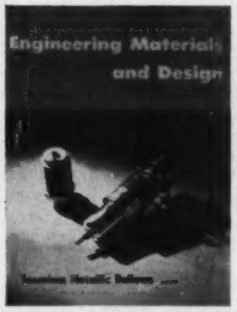

COVER: One of a range of 15 kV high vacuum variable capacitors developed by the English Electric Valve Co. The bellows on the left allows one set of capacity plates to be moved without the vacuum dielectric being broken.

Published monthly by HEYWOOD & COMPANY LTD., Drury House, Russell Street, London, W.C.2 (Tel.: TEMple Bar 3422), on the 15th of the preceding month. Annual subscription 35s. sterling per annum ($5.25, U.S.A. and Canada) throughout the world. Single copies to order from all newsagents and bookstalls, 2s. 6d. each) by post from the publishers, 3s. 0d. each). BRANCH OFFICES: Royal Buildings, 2 Mosley Street, Manchester, 2, Tel.: Central 9935; Bayliss House, Hurst Street, Birmingham, Tel.: Midland 5786; 52 St. Enoch Square, Glasgow, Tel.: City 3492; 527 Madison Avenue, New York, 22, N.Y., Tel.: Plaza 9-1171.

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ISSUE AT A GLANCE

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HIGH-STRENGTH 12% Cr STEELS **606**
Description of the Jethete series of heat-treatable stainless steels.
By **K. J. Irvine**, B.Sc., Ph.D., and **J. D. Murray**, A.Met., A.I.M.

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Discussion of the various uses and potentialities.
By **Leo Walter**, A.M.I.Mech.E.

ZINC DIE CASTINGS VERSUS PLASTICS MOULDINGS **622**
Explanation of the advantages and disadvantages of these two types of product.
By **G. FitzGerald-Lee**, F.R.Econ.S., M.I.E.I., A.R.Ae.S.

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Survey of plastics which are becoming available for use as bearing surfaces.
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Résumés

MOULAGES EN MATRICES EN ZINC OU EN MATIÈRES PLASTIQUES

ar G. FitzGerald-Lee page 622

L'auteur passe en revue les principaux avantages et inconvénients de ces deux types de produits.

PALIERS AUTO-LUBRÉFIÉS

par Pauline Long page 626

Cet article a pour objet d'indiquer les diverses matières plastiques que l'on peut utiliser, aujourd'hui, dans la fabrication des paliers. Il insiste surtout sur les matériaux qui rendent inutile le graissage normal ou le réduisent appréciablement.

UN SOUFFLET MÉTALLIQUE SANS SOUDURE

par L. Walter page 618

L'auteur décrit les soufflets métalliques fabriqués sans soudure et explique comment on peut s'en servir comme simple ressort, comme dispositif pour la détection de changement de pression ou pour compenser les variations structurelles dans les tuyauteries.

ACIERS Cr 12% À FORTE RÉSISTANCE

par K. J. Irvine et J. D. Murray page 606

Les aciers inoxydables à Cr 12% pouvant être traités par la chaleur sont utilisés de plus en plus dans la construction de structures destinées à rester dans un milieu à température élevée. Les auteurs traitent, dans cet article, de la série de Jethete.

EXPOSITION DES ÉQUIPEMENTS D'USINE

page 649

Une revue de quelques-uns des matériaux et dessins que l'on a pu trouver à Manchester, du 21 septembre au 1er octobre.

Kurzreferate

ZINKSPRITZGUSS UND KUNSTSTOFFORMUNG

von G. Fitzgerald-Lee Seite 622

Der Verfasser bespricht die grundsätzlichen Vor- und Nachteile dieser beiden Arten von Fabrikaten.

SELBSTSCHMIERENDE LAGER

von Pauline Long Seite 626

Der Artikel verfolgt den Zweck, die verschiedenen Kunststoffe, welche heute als Baustoffe für Lagerflächen verfügbar sind, zu besprechen, und dies mit besonderem Hinblick auf jene, welche normale Abschmierung entweder vollkommen beseitigen oder sie auf ein Mindestmass reduzieren.

NAHTLOSE METALLBÄLGE

von L. Walter Seite 618

Der Verfasser beschreibt die Entwicklung von nahtlosen Metallbälgen und zeigt ihren Einsatz als einfache Feder, als druckempfindliches Organ oder zur Aufnahme von strukturellen Änderungen in Rohrleitungen.

HOCHFESTE 12% Cr-STÄHLE

von K. J. Irvine und J. D. Murray Seite 606

12% Cr-Stähle, die sich hitzeverfestigen lassen, finden dauernd steigenden Einsatz bei strukturellen Anwendungen in Hochtemperaturanlagen. Der Artikel befasst sich mit der Jethete Serie.

AUSSTELLUNG VON FABRIKSEINRICHTUNGEN

Seite 649

Eine Übersicht einiger neuer Baustoffe und Einrichtungen, die in Manchester vom 21. September bis zum 1. Oktober zur Ausstellung gelangen.

Резюме

ЦИНКОВЫЕ ШТАМПОВКИ И ПЛАСТМАССОВЫЕ ФОРМОВКИ

Дж. Фитцджеральд-Ли стр. 622

Автор подробно описывает основные преимущества и недостатки этих двух типов изделий.

САМОСМАЗЫВАЮЩИЕСЯ ПОДШИПНИКИ

Полина Лонг стр. 626

Цель статьи — охарактеризовать различные пластики, пригодные для использования в подшипниках, причем особое внимание уделяется тем сортам, которые либо совершенно удалили необходимость обычной смазки, либо значительно ее сократили.

БЕСШОВНЫЕ МЕТАЛЛИЧЕСКИЕ ГАРМОНИКИ

Л. Уолтер стр. 618

Автор рассказывает о развитии бесшовных металлических гармоник и о том, как их можно использовать в виде простых пружин, устройств для измерения давлений, или компенсаторов в трубопроводах.

ВЫСОКОПРОЧНАЯ 12-ПРОЦЕНТНАЯ ХРОМИСТАЯ СТАЛЬ

К. Дж. Ирвин и Дж. Д. Марри стр. 606

Термообрабатываемая нержавеющая сталь, содержащая 12% хрома, находит себе все более широкое применение в условиях повышенной температуры. В этой статье авторы разбирают стали марки «Джетхит».

ВЫСТАВКА ФАБРИЧНОГО ОБОРУДОВАНИЯ

стр. 649

Обзор некоторых новых материалов и конструкций, показанных в Манчестере с 21 сентября по 1 октября.

MATERIALS IN THE NEWS

Monthly Digest of Materials and Design News from Home and Abroad

Wood Laminates in Cathodic Protection

CATHODIC PROTECTION is playing an increasingly important part in preventing corrosion on external hull surfaces, and recent developments in this field are meeting with considerable success. One of the problems involved in the "sacrificial anode" system of cathodic protection is finding a mounting material for the magnesium anode which not only provides good insulation, but also has strong corrosion resistant properties. A material claimed to overcome this problem is a grade of Permali densified wood laminate, developed specially for this application.

During prolonged tests, the magnesium anode was mounted on a Permali block and the complete assembly was then placed at the lower-water mark of sheet piling in Birdham Pool. Periodic inspection to ensure that the anode was working against the sheet piling showed the pH of deposits on the mounting to be 9. This assembly was left in position for nearly two years, and finally removed when the anode had been completely consumed. At the first inspection no sign of any degradation was found on the mounting, and further laboratory tests which were carried out showed that the Permali blocks were still above their guaranteed minimum values, even after two years arduous duty.

Insulation resistance measurements which were made between the holes in the panel showed values ranging from 90—227 megohms. After the whole panel had been immersed in water for a further 24 hours and then re-tested, the insulation resistance had dropped to 0.2—0.5 megohms—a very satisfactory result considering the length of time the panel had been immersed in water.

Permali also offers a potential and unusual advantage as a non-metallic fastening material in the form of bolts and nuts. Although the tensile breaking load of a new ¾-in. brass bolt and nut assembly is approximately 5,500 lb., it falls rapidly after a period of service, whereas a Permali ¾-in. nut and bolt assembly, which has a tensile strength of approximately 4,000 lb., is said to maintain its strength in service almost indefinitely.

Nuclear Jet Submarine

INFORMATION HAS RECENTLY BEEN released concerning the design study of a nuclear jet submarine capable of very high speeds. During the opening speech by Dr. Barnes Wallis at the Engineering Materials and Design exhibition and conference, in February, it was mentioned that a British company had, several years ago, conducted research into the possibility of large underwater cargo ships, and had defined a shape that would permit high speeds without the use of excessive powers. Subsequently the Mitchell Engineering Co. has been considering in greater detail a vessel of this sort, while both in the U.S. and on the Continent the use of aluminium as a material of construction for these submarines has been investigated.

These basic considerations, together with the new form of underwater nuclear jet engine conceived by the Boeing Airplane Co., might well form a formidable combination resulting in an economical form of bulk transport. The engine, at present the subject of a patent application, is a similar concept to the jet turbine engine for air vehicles. The water is passed under ram pressure through a nuclear heat exchanger, then through a turbine to be ejected in the form of steam and water at a high exit velocity from a nozzle, thus providing thrust. From the studies already made it has been estimated that, with a 2-ft. dia. nozzle, speeds greater than 100 m.p.h. can be attained. The many problems involved in producing such an engine can be well imagined, but these technical difficulties will undoubtedly be overcome, and it is possible that the engine may eventually appear as a combination of turbine jet and ram jet, thus opening up even greater possibilities.

Hot Extruded Ductile Cast Iron

DURING RECENT YEARS there has been a continued increase in the use of ductile (also called "nodular") cast iron as an engineering metal. This material possesses casting characteristics equal to those of grey cast iron. Proper heat treatment can produce a variety of mechanical properties, ranging from 160,000 p.s.i. tensile strength with 2-5 per cent elongation to 75,000 p.s.i. tensile strength with 25 per cent elongation. Ductile iron is more easily machined than grey iron and mild steels, has very good wear resistance, and is very useful for applications where pressure tightness is required. In some applications, savings have been realised by replacing intricate steel forgings or welded structures with ductile iron castings. Ductile iron has also been successfully hot forged and hot rolled under laboratory conditions. The ability to extrude this material into bar stock, tubes, and structural shapes would add considerably to its potential applications.

The purpose of a recent investigation by Watertown Arsenal Laboratories, U.S.A., was to investigate on a limited scale the extrudability of ductile cast iron, and to determine the mechanical properties of tubular and round sections as-extruded and after selected treatments.

The extrusions varied in quality from sound sections of good surface to badly ruptured pieces. The behaviour was so irregular as to suggest non-uniformity of the billets; however, such was not disclosed by inspection prior to extrusion. The sound material possessed high strength, but negligible ductility, as-extruded. After annealing at 930 deg. C. and slow cooling, or after quenching from 930 deg. C. and tempering at 570 or 620 deg. C., excellent combinations of strength and ductility were realised, somewhat superior to those of cast ductile iron. However, the highest room temperature Charpy V-notch impact strength values were only several ft.lb.; these resulted from quenching and tempering at 620 deg. C. All other treatments developed negligible impact strength at room temperature. At 200 deg. C., extruded material annealed or quenched and tempered at 570 or 620 deg. C. possessed approximately 10 ft.lb. impact strength.

These results indicate that ductile cast iron may be extruded and heat treated to produce bar stock possessing good strength and ductility. This development is important, since it shows a new and flexible combination of melting and conversion facilities for the manufacture of structural sections. Whereas steel sections require the extensive melting and rolling facilities of a steel mill, extruded cast iron sections can be manufactured through the integration of an iron foundry and an extrusion press. Cupola melting will permit easy recycling of foundry and extrusion scrap, and billets can be cast to the proper dimensions, including an internal bore if tubes are to be extruded. By proper selection of composition, internal shrinkage of the billet castings, and the associated need for risering, can be obviated. Available data show that ductile cast iron is readily extrudable at 980 deg. C. (although this has not been determined as the optimum temperature). Steel, by comparison, is less plastic and would require heavier presses to accomplish an equivalent reduction at that temperature.

PICTURE NEWS

IN THE WORLD OF MATERIALS & DESIGN

ELECTRO-HYDRAULIC TRACER CONTROL

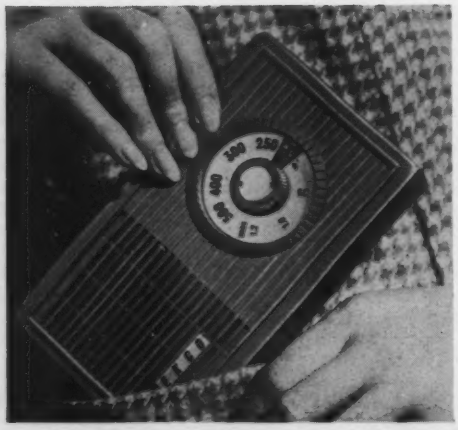
Shown below is a new automatic control system which is described as providing unprecedented flexibility and accuracy in the operating of engine lathes. Introduced by Minneapolis-Honeywell, it is said to turn out components that are impossible to produce manually on a lathe, and to be capable of machining elliptical and square parts, as well as glass and plastic mould dies.

AUTOMATIC LOADER USES HYDRAULICS

The Lodematic loader shown above is designed for single-handed operation, using a hydraulic system. On receipt of the load the platform lifts, halts automatically at any intermediate height, and descends when unloaded.

SLOW-MOTION TUNING ON POCKET RADIO

A new pocket portable radio receiver (Ekco Model PT352) shown at the 1960 Radio Show measures only $1\frac{3}{4} \times 3\frac{3}{8} \times 6\frac{1}{2}$ in., and is a truly pocketable receiver. The all-transistor circuit has push-pull output, and an unusual feature for such a small model is slow-motion tuning for easy separation of stations.



A LIGHT FROM SUNLIGHT

This solar cigarette lighter (right) lights a cigarette in about 5 seconds by focusing the sun's rays on the cigarette tip. The lighter is made of highly polished aluminium sheet, supplied by Aluminium Company of America, and two sizes are available.

ZINC ALLOY CHEAPENS PRODUCTION

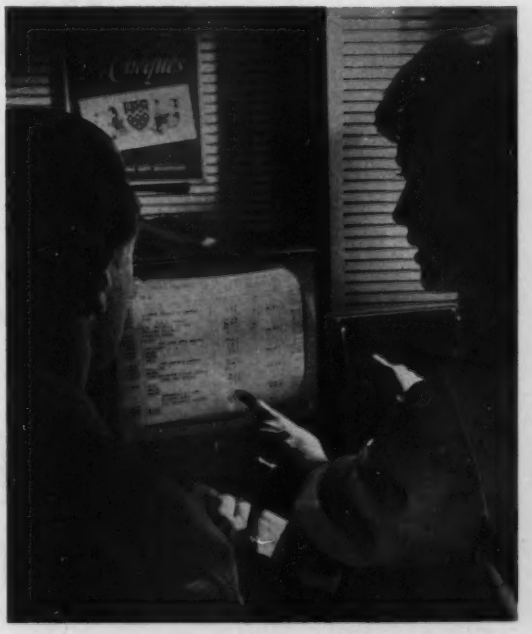
This compact unit houses the intricate workings of a vehicle speed control mechanism that permits the driver to achieve and maintain any desired speed, either automatically or under manual control. Marketed as Speedostat, by Perfect Circle Corp., U.S.A., the unit relies on precisely maintained dimensional tolerances achieved by die casting.

HYDROSTATIC TRANSMISSION

A Fordson tractor fitted with the Dowmatic transmission showing its paces on a 1 in 1 incline at the Dowty factory at Ashchurch. The Dowmatic drive is an infinitely variable speed hydrostatic transmission, utilising the positive displacement of oil between a pump and motor, and is suitable for applications up to 60 h.p.

PRECISE LOCATION ON TAPE

The outstanding feature of the D.G.4 dictating machine (made by the Fonadek Group) is its direct positive tape location system, which allows the precise pin-pointing of any part of the tape. This means that any letter that has to be signed urgently can be located immediately by the typist, using the simple tabulator, and transcribed straight away.



"IN THE RED" IN BLACK AND WHITE!

The Westminster Bank in Manchester has introduced the first inter-branch television network (developed by the Pye Group), whereby customers can check their accounts on private television screens which relay pictures from a centralised book-keeping department nearly a mile away.

Protection for Aluminium

. . . on unfinished or painted products

with the

BONDERITE 700

SERIES

and Pylumin

also new

Aluma Etch

(Marketed under licence of U.K. Patent No. 731,035)

A scale free, controlled alkaline etchant for uniformly etching aluminium surfaces.

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400 kV Reactors

SWEDEN IS RICH in hydraulic resources, but the majority of these are located in the North of the country, whereas the largest industrial zone lies in the South. This circumstance necessitates the use of long, very high voltage lines for connecting the generating and consumer centres, with the minimum of loss. It is well known that when lines of the order of 250 miles in length operate unloaded, their capacitative characteristic results in the production of large overvoltages at the far end of the line.

Inductive impedances must necessarily be employed in order to correct the effect of the capacity. Up to the present time, compensation inductances have always been connected to a low voltage tertiary winding of the power transformers, in view of the great difficulties involved in the insulation and adjustment of very high voltage inductances. Owing to the inherent losses, this old-fashioned procedure did not enable the full power of the transformers to be utilised, even in cases where synchronous compensators were connected to the 20 kV tertiary winding.

The Swedish State Power Board has examined this problem, and has decided to adopt an advanced solution—direct compensation of the very high voltage lines. The design and construction of the 400 kV reactors has been confided to a large Belgian electrical manufacturing firm (Ateliers de Constructions Electriques de Charleroi), which has exceptionally wide experience in the construction of high power very-high-voltage transformers. It is of interest to note that these shunt reactors will be the most powerful in the world.

This innovation will provide the advantage of enabling the line transformers to handle a larger active power.

Such an elegant technical solution has, however, called for a very careful examination of the problem presented by the mechanical vibrations and resonances, which may attain a dangerous amplitude, and also the problem of obtaining inductance values on all three phases, which are within 0.5 per cent of one another. This is necessary in order to prevent the development of a zero sequence earth current, which might interfere with telephone and radio communications in the region. The very complicated design of these reactors would normally have required 16,000 hours of work; this time was very considerably reduced by the use of an analogue model and digital computer.

International Fluid Seal Meeting

THE BRITISH HYDROMECHANICS RESEARCH ASSOCIATION are to hold an international meeting on fluid sealing from April 17-19 1961, at Grosvenor Hall, Ashford, Kent. Papers will be given on technical advances in fluid sealing, and opportunities will be provided for discussion between workers in this and related fields. The topics will be classified under four main headings: liquid seals, gas seals, sealing materials and miscellaneous, the latter covering seals for extreme conditions of speed, pressure and temperature, and other special sealing techniques not covered by the other three sections. Full details can be obtained from the B.H.R.A., who would welcome contributions. It is hoped that each paper will make a fundamental contribution to the theory of sealing or a related topic.

Self-sealing Ceramic

CAPABLE OF DEVELOPING its own protective coating in the face of heat and oxidation, and also of instantaneously mending any cracks in its protective layer, as they may occur, from its own base material, a new ceramic graphite-base material has been developed experimentally by the Boeing Airplane Co. While not yet considered sufficient for design data, the test results so far obtained have proved very interesting, and could be useful to a number of high-temperature projects now in the process of development. Known as a composite graphite body, the new material is being studied through a company-sponsored research programme which includes various compositions of graphite and ceramic powders.

While normal graphite materials have a good strength-to-weight ratio at very high temperatures, and being non-melting, sublime at around 3600 deg. C. (solid changing to gas), they are limited in use, apart from their brittleness, because of the tendency of graphite to oxidise in strong oxidising high-temperature environments. To overcome this, coatings must be used. It is at this point that the composite graphite body may become important, since it forms its own protective coating, and the need for separate, additional protection is obviated. Its maximum tension and compression capability is about double that of standard graphite at room temperature, while it also has a strength advantage at temperatures above 1650 deg. C. When it is suddenly plunged into furnace heat, the protective layer immediately forms.

The new self-sealing ceramic under test at 1420 deg. C. in an oxy-acetylene flame.

In a typical test, a small rectangular bar was clamped between water-cooled graphite electrodes and resistively heated to 1650 deg. C. in less than 1 min. After 3 min., the temperature was 1820 deg. C. and remained approximately constant for 15 min. The protective surface appeared as a viscous, glassy layer agitated by a slow, continual "boil off" of gaseous material. The glassy material remained on the surface and continued to provide a measure of protection to the material beneath, even after becoming liquid.

Yttrium Fabrication

YTTRIUM HAS PARTICULARLY ATTRACTIVE properties for use in nuclear reactors, including a relatively low capture cross section for neutrons and relative inertness to uranium. Attempts have been made to fabricate material for the construction of an yttrium loop to be used for containing molten uranium, but the material was practically unworkable, and considerable difficulty was encountered. This brittleness problem led to the development work published in a recent report by the U.S. Atomic Energy Commission.

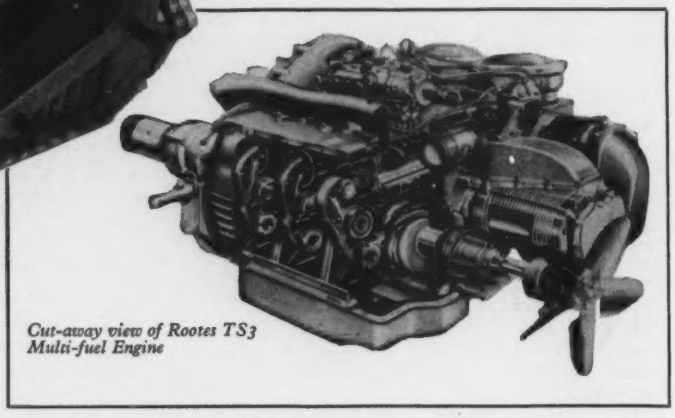
The research was primarily concerned with establishing practical and economical methods of fabricating semi-finished shapes from arc-melted yttrium billets. The various methods investigated were hot extrusion, hot and cold rolling, rod and tube drawing, and swaging. In addition, since very little information was revealed by a survey of literature, certain properties of the metal also had to be investigated, including the extent of oxidation at various temperatures, annealing and recrystallization temperatures for cold-worked metal, and temperatures of formation of a liquidus between yttrium and copper (used for cladding during extrusion).

A preliminary investigation revealed that vacuum annealing at 590 deg. C. is satisfactory for softening cold worked material. The oxidation of bare yttrium metal was observed to be quite rapid at temperatures above 480 deg. C. The formation of copper-yttrium compounds at extruded interfaces was also observed to occur at temperatures as low as 510 deg. C.

NICKEL ALLOY STEELS

for quiet efficiency

Wade supercharger



Cut-away view of Rootes TS3 Multi-fuel Engine

Superchargers are widely used in oil engines for pressure charging and scavenging and are essential in the opposed piston type. One of the best known designs is the 'Roots-type' supercharger, made in this country by Wade Engineering Ltd., Brighton.

Quiet operation and maximum overall efficiency are required and a well-designed single helical pair of gears meets these requirements. The driving gear which meshes with a bronze wheel is made from En24V steel and the drive shaft, which has a serrated bore, from En100.

Wade Superchargers are fitted on TS3 opposed piston oil engines made by the Rootes Group to provide versatile and reliable power producers needing little maintenance.

TYPICAL MECHANICAL PROPERTIES OF

EN24

Typical mechanical properties of EN24 steel, exemplifying its versatility both as regards strength and range of serviceable section sizes, are as follows:

SIZE	HEAT TREATMENT	YIELD STRESS t.s.i.	MAXIMUM STRESS t.s.i.	ELONGATION per cent	IZOD ft. lb.
0.564 in. dia.	Oil quenched 830°C tempered 200°C	111	125	14	24
1½ in. dia.	Oil quenched 850°C tempered 510°C	79	83	15	28
1½ in. dia.	Oil quenched 850°C tempered 560°C	68	73	19	55
2½ in. dia.	Oil quenched 840°C tempered 650°C	57	64	20	65
5¾ in. dia.	Oil quenched 830°C tempered 650°C	50	58	19	75

By utilising the better properties obtainable in more highly alloyed nickel steels, dimensions can be reduced, lighter constructions produced, distortion through heat treatment minimised and reliability and economy achieved.

Please send for our publications entitled 'The Mechanical Properties of Nickel Alloy Steels' and 'The Case Hardening of Nickel Alloy Steels'

MOND NICKEL

THE MOND NICKEL COMPANY LIMITED, THAMES HOUSE, MILLBANK, LONDON, SW1

TGA31/2/1C

Joint British Committee for Stress Analysis

FOLLOWING AN EXPLORATORY MEETING on March 1, 1960, arranged by the Institute of Physics, a Joint British Committee for Stress Analysis has been set up in Great Britain. This Committee will represent the interests of Great Britain in the field of stress analysis at the periodic meetings of the Permanent Committee, which are held in Europe.

The principal object of the Permanent Committee, membership of which is open to all West European countries, is the furtherance of international collaboration in the field of stress analysis, and in seeking to achieve this end international conferences will be arranged at four-year intervals. Such conferences will normally be phased with the International Congresses on Applied Mechanics. The officials and secretariat of the Permanent Committee will normally be appointed by the National Committee of the country in which the next international conference is due to be held.

The aims of the Joint British Committee for Stress Analysis will be to act in the collective interest of the constituent bodies: (a) by maintaining liaison with the Permanent Committee for European or international conferences on stress analysis, and (b) by maintaining liaison with overseas societies and institutions concerned with stress analysis. Mr. A. F. C. Brown (of the National Physical Laboratory), the representative of the Institution of Mechanical Engineers, has been elected the first chairman of the Committee, and the Institution of Mechanical Engineers provides the secretariat for the Committee.

Exploding Wire

THE DESIGN ENGINEER in the electronic and other engineering fields now has available to him a new and very interesting tool. A wire (Pyrofuze) has been developed by the Sigmund Cohn Corp. which, when heated to about 650 deg. C., either by passing current through it or otherwise, ignites with explosive violence and reaches a temperature of about 2000 deg. C. Perhaps the most interesting aspect of this reaction is that the total energy developed as heat far exceeds the energy necessary for the initial ignition. The wire is strong and ductile, and has a sufficiently high tensile strength to enable it to be easily handled in most manufacturing operations.

The unusual behaviour of this wire is due to the fact that it consists of two separate metals, between which an exothermic alloying reaction takes place after a critical temperature has been reached. It has been observed that when either aluminium or magnesium is alloyed with either platinum or palladium, considerable heat energy is very rapidly released. It is possible that a chemical compound is formed, and there is reason to suspect that in the case of palladium and aluminium the compond is Pd-Al.

THE NOVEMBER ISSUE

of Engineering Materials and Design will include the following main features:

Properties of Rubber
Mechanical, static and dynamic properties; and design of components.

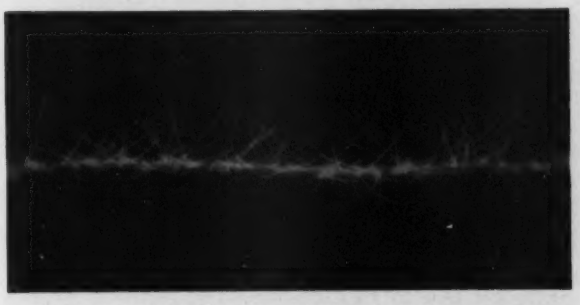
Effect of Irradiation on Structural Steels
Brittle fracture characteristics, and other mechanical properties.

Translation of Russian Technical Journals
Survey of those journals currently available in English.

Diesel Engines up to 300 b.h.p.
Design features and tabulated data.

The above principle is put to practical application by cladding an aluminium wire with a jacket or shell of palladium. This is usually done in such a manner that the metals are present in equal proportions on a volumetric basis. The great ductility of both metals makes it possible to draw the composite wire as small as 0.001 in. dia.; however, most investigators have experimented with somewhat larger sizes. It is possible to make wire of this type using a platinum jacket, but the most satisfactory results have been obtained with palladium. In addition, palladium is considerably cheaper than platinum, both on a price basis and also because the specific gravity is approximately half that of platinum. Palladium is therefore preferred.

Initial experiments with Pyrofuze wire indicate that it may have applications in the field of detonating devices, where



Photograph of a 0.003 in. dia. palladium clad aluminium wire, less than 5 milliseconds after ignition.

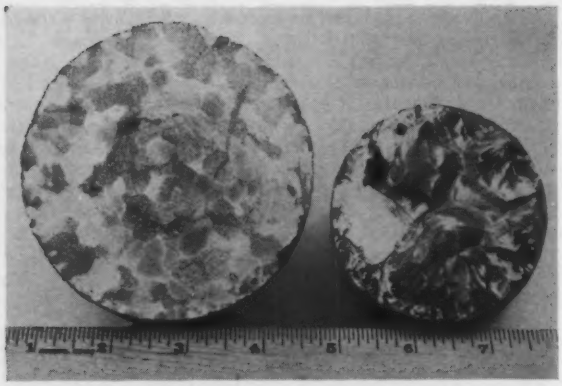
advantage may be taken of the fact that the total energy available as heat exceeds the energy necessary to initiate the action—there is therefore a gain in total available energy, which is unique for a metal wire. Experiments have demonstrated that the reaction occurs satisfactorily in an inert atmosphere, or in a vacuum, or (when fired electrically by passing a current through it) even under water ! The presence of oxygen is not necessary for the reaction to occur. If the wire is ignited at one end, the reaction will proceed rapidly along the length of the wire.

Extrusion of Brittle Materials

AT THE NATIONAL ENGINEERING LABORATORY attempts are being made to extrude materials like magnesium and bismuth, which when extruded cold in the ordinary way become so badly cracked that the product is useless. In deformation processes such as extrusion and rolling, the flow of metal is constrained in such a way that the deformation takes place in the presence of a hydrostatic stress which may be considerably greater than the yield stress of the material. In general, the ductility of a material increases with increase of hydrostatic pressure, and this explains why strains many times larger than the fracture strain indicated by the normal mechanical tests can often be obtained in formation processes.

Tests have been made to see whether cracking of the product when extruding brittle materials at only a fairly small reduction in area could be prevented by increasing the hydrostatic stress above that caused by the normal extrusion load. This has been done by carrying out the extrusion inside a chamber filled with fluid which can be pressurised up to 60 t.s.i. It has been found that there is a critical fluid pressure at which cracking is prevented; this critical pressure varies with the extrusion ratio. Further work is being carried out to investigate this in more detail.

It is hoped to develop these techniques to the stage where high-pressure forming can be used industrially. One important application would be the manufacture of cans for containing the fuel elements in nuclear reactors. Cans of magnesium alloy can be produced by hot-forming processes, but the improved mechanical properties obtained with cold-forming operations would be of considerable practical importance. The possibility of extruding cans of pure beryllium is also attractive, since beryllium is a notoriously difficult material to work using conventional machining processes.



The fine-grain crystal structure in an ingot of tungsten cast by Stauffer-Temescal's new process is revealed by the cathodically etched ingot cross-section on the left. An ingot of tungsten cast by the old method is shown on the right.

Grain-Refined Tungsten and Molybdenum

A NEW TECHNIQUE for substantially reducing grain size in electron-beam melted and cast refractory metals and alloys has greatly improved their working characteristics. The development, by Stauffer-Temescal Co., of a general technique for reducing grain size in cast ingot represents a major breakthrough in refractory metals technology. The method employs a combination of electron-beam processing and critical composition control, and is effective with all the refractory alloys so far tested.

The most significant effect is a marked improvement in fabricability. While ductile refractory alloys had previously been produced by the grain-boundary refining action of electron-beam melting, the more refractory metals, particularly pure tungsten and molybdenum, still presented serious problems in fabrication, due to the large crystal structure always present in the cast ingot. The presence of these large crystals made deformation failure along lines of crystallographic weakness a common occurrence. Thus, cast tungsten ingot would frequently rupture under the stress of forging. Reduction of grain size reduces the directionality of the material by introducing an element of randomness to the crystal structure. Fine grain crystals are less likely to be aligned along common planes, and therefore stresses are more evenly absorbed.

Among other effects said to be imparted to tungsten and molybdenum by the new casting technique are improved ultimate strength in the annealed condition and after 90 per cent cold work, and a reduction in the effect of cold work. Molybdenum cast by the new process does not require extrusion before forging in a closed-die forge. Moreover, these properties are not markedly affected by recrystallization during reheating or welding.

Leak Detection with Radioisotopes

A METHOD FOR DETECTING LEAKS at a rate of less than one sixty millionth part of a cubic inch per day will be illustrated in the United Kingdom Atomic Energy Authority's exhibit at the Fifth International Instruments and Measurements Exhibition (September 10-17, in Stockholm). The method uses a radioisotope technique, and has been developed by the Wantage Research Laboratory.

Corresponding to a cube of about one four-hundreth of an inch side, a sixty-millionth of a cubic inch appears to be a very small volume, yet it can contain seven million million atoms of the radio-active gas used in this particular application. Since, initially, some 16,000 of these atoms would decay and emit tell-tale radiation each second, detection of their presence and calculation of the rate of leakage can be carried out with comparative ease.

To determine the rate at which leaks in sealed components would admit air or other gases, these are immersed in an atmosphere of radioactive krypton-85 gas, which is raised to a known pressure for a fixed period of time. After the components have been removed from the gas, the amounts of krypton which have found their way into the objects under test are determined by measuring the emitted radiation with a counter.

For outward leakage, the component is filled to the required pressure with a known specific activity of the gas. Then, either the escaping gas is collected and assayed with a counter, or measurements are made of the decrease oven a period of time in the intensity of radiation emitted from the component. The latter is the most reliable method, as a leak can become temporarily blocked.

Tests of small articles such as transistors (of which the life is shortened if oxygen or water vapour penetrates their containers) are best made by immersing them in the gas. Sensitivity is reported to be about 100 times better than with a helium mass spectrometer.

Painting Metal-sprayed Steel

DURING THE LAST TWENTY YEARS the use of sprayed metal coatings of aluminium or zinc to protect structural steelwork has grown in importance, and this method of protection is now frequently specified by consulting engineers for structures to be erected both at home and abroad. So far as is known, satisfactory results have been obtained in the majortiy of cases, but recently there have been several instances of premature failure of the protective scheme in important structures treated in this way.

These observations have led to doubts regarding the merits of sprayed metal coatings beneath paint for the protection of structural steel. It is, therefore, important to clarify the position and lay down the conditions under which properly chosen and well applied composite protective schemes of sprayed metal coatings and paint can be relied on to protect steel satisfactorily for specified periods.

The British Iron and Steel Research Association, through its Corrosion Advice Bureau, is taking the initiative in doing this, by organising a collaborative investigation with the financial support of all who may be interested in the subject. Direct approaches have been made to the various trade associations and professional bodies concerned, but any others, including individual firms, who would like to participate are invited to write to the Secretary, Corrosion Advice Bureau, B.I.S.R.A., 140 Battersea Park Road, London, S.W.11.

Magnox Stainless Steel Welds

A GAS-WELDED SEALING JOINT between Magnox—a magnesium alloy containing small amounts of aluminium, beryllium, iron and silicon—and stainless steel is being successfully made by the United Kingdom Atomic Energy Authority. This is the first time that these two materials have been joined in this way. This latest process, involving the use of Tinflux, was developed by British Oxygen Gases Ltd. in co-operation with the U.K.A.E.A., and follows an earlier technique adopted for the welding of dissimilar metals.

The present application is carried out on special bolts used to secure canisters in position for deadweight load and pressure tests. Bolt stems of stainless steel are fitted with Magnox bushes under the heads. A " welded " seal is made between the bushes and the bolt heads. Recesses in the bushes form joints with the tops of the canisters and act as vacuum-tight seals during testing. The Magnox canisters are designed to hold radioactive material, and to operate within an atomic pile.

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THE HUMAN ELEMENT IN INDUSTRY

VIDEOSONIC TRAINING

ASPECTS of the human element in industry occupy little space in our Journal, yet these are fundamental foundations in the birth and growth of any industrial organisation. That the management of Hughes International (U.K.) Ltd., whose new factory was recently opened in Scotland, is in agreement with this sentiment was made obvious during a speech at the opening ceremony by the vice-president of the U.S. parent company, when he stated that the human element was the most important factor in establishing and expanding a business. The American company is one of the largest manufacturers of semi-conductors in the U.S., and in choosing Scotland as the centre of production for the European market a suggestion on the future of Scotland's industries made by our correspondent in the February issue of E.M.D. is being fulfilled.

In this new subsidiary company, production is in the hands of girls who are trained from a school-leaving age of 15 years, and who are selected on a basis of dexterity and intelligence. Only some 20 per cent of all applicants are accepted for training (this is considered to be a comparatively high figure), and of these only 5 per cent are subsequently found unsuitable, which recommends the new method of training, "Videosonics," introduced at the plant.

With this system, a tape-recorded voice describes each movement that should be made, and coloured slides provide a visual guide to accompany the oral instructions. The assembly of semi-conductors is work that requires a delicate touch, patience, and an appropriate attitude of mind.

Since this "Videosonic" system has been so successful in producing this type of high precision component, it is highly probable that a similar form of selection would also benefit other types of industry.

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NO DESIGN DIPLOMA YET

THE case for instituting a Diploma of Design was the subject of a recent debate at the Institution of Engineering Designers. Mr. W. A. A. Witham, in presenting the case, said: "We want to provide an award for the designer who is prepared to make the extra effort, and, in addition, to set a new and exacting standard in engineering design. Only by introducing a course and examination of a worth-while standard can we ever hope to gain the general respect of industry, which at present is sadly lacking."

How much we endorse the sentiments expressed in those words! However, before we get carried away by enthusiasm, there are many points to be considered both for and against the proposal, which must be very carefully conceived and receive the widest possible support if it is to achieve its object. We agree that, to be really effective in proving creative design ability, an examination must involve a complete design project, and this does not seem to be beyond the bounds of practicability, as the R.I.B.A. already operate a similar scheme. There will undoubtedly be problems in setting and marking papers, and financing the examination may prove difficult, but before the practical details are worked out the full objective of holding a special examination must be agreed upon.

Creative ability, which is such an essential quality in a designer, can take many forms, ranging from the natural genius which enables a man to start off with a blank sheet of paper and produce original designs, to the logical mind which enables him to produce new ideas over many years by trial and error. The man with a naturally creative outlook is frequently difficult to control and discipline, so that employers often favour the trial-and-error approach, which is based on sound experience. British engineering has in the past relied very largely on this approach to design, but there are obvious signs that a greater emphasis on originality is needed. A qualification like the suggested Diploma of Design might well provide a much-needed stimulus by helping men with the necessary qualification to reach responsible design posts at an earlier age.

It is often said that "designers are born, not made", and whilst this may be partially true of a few specially brilliant individuals, we feel that latent powers exist in many men who never exert themselves in the direction of design unless forced to by circumstances. Many men pass through colleges to industry with a general engineering education, and by chance get involved with design. If at this stage they then desire to take a Diploma examination in design, considerable study and work in leisure hours is necessary; but such concentration on one subject might perpetuate the narrow-minded attitude which is already a characteristic of so many drawing offices today. Would it not be better for the budding designer to broaden his scope, for instance by learning a foreign language or by taking up some unrelated subject which will help him to keep a balanced view of the world for which he is designing products? A porous plastics battery separator was recently invented as a result of the study of the sintering of metal powders, and many other examples can be quoted of cases where broad knowledge coupled with common sense made a good substitute for natural genius.

We hope that Mr. Witham's defeat in debate at the I.E.D. by a two to one majority will not discourage him. Only a very small proportion of the total membership was present to vote, so that the meeting was not necessarily representative of designers as a whole. However, the I.E.D. deserve every credit for sponsoring this debate, and we cannot help feeling that whether the motion was carried or not is of little consequence. More will undoubtedly be heard of this, and we expect the debate to continue in factories, offices and canteens. May we remind you that our columns are also available for publishing readers' opinions.

The Editor

HIGH-STRENGTH 12% Cr STEELS

The 12 per cent Cr heat-treatable stainless steels are finding increased structural applications in elevated temperature environments—here the authors describe the Jethete series

by K. J. IRVINE, B.Sc., Ph.D., and J. D. Murray, A.Met., A.I.M. *

THE stainless steels which are commonly used fall into several main types with different combinations of oxidation resistance and mechanical properties. One important type is the 12 per cent Cr transformable steel, which is finding increasing application as a high strength stainless structural steel. In recent years the Jethete series of steels has been developed, which offers very attractive combinations of mechanical properties and creep strength, and these are now being increasingly used by the aircraft and steam power plant industries. A brief description of these steels, together with a summary of their properties, is given in this article, and from the comparison of the properties it is possible to select the appropriate steel for different applications.

Twelve per cent Cr steels are rather difficult to develop because of the critical importance of composition. If 0·1 C, 12 per cent Cr is selected as the base composition (which is desirable for the best combination of strength and ductility), then this steel is on the borderline of the austenite/ferrite phase field at solution temperatures, and any addition of ferrite-forming alloying elements such as molybdenum, vanadium, niobium and titanium will produce appreciable amounts of ferrite in the microstructure, which has an adverse effect on the mechanical properties. Consequently, any addition of a ferrite-forming alloying element must be balanced by the austenite-formers nickel, manganese and copper. Another feature of these steels is the effect of the alloying elements in depressing the Ac_1 and Ms phase transformation temperatures. If the Ac_1 temperature is depressed below 700 deg. C. this can create difficulties during tempering, because re-austenitisation will occur during the tempering operation and martensite will subsequently form on cooling to room temperature. Not only does this make the steel difficult to soften but an undesirable combination of mechanical properties is produced. With regard to the martensite transformation range, if this is depressed so that the M_f is below room temperature then some residual austenite remains in the microstructure on cooling to room temperature following solution treatment. This residual austenite also has an adverse effect on the mechanical properties, and for this reason the M_f temperature must desirably not be below 50 deg. C. When considering variations in composition, therefore, it is necessary to consider not only the desired effects of the alloying elements, such as improvement in tempering resistance or high temperature properties, but also the associated effects on the microstructure and transformation points. Since the Jethete series of steels is based on the 0·1 C, 12 per cent Cr base composition it is useful to consider the structure and mechanical properties of this steel first.

Low C, 12 per cent Cr Base Steel

Low C, 12 per cent Cr steel has been used for many applications, such as aircraft compressor discs and blades and steam power turbine blades. One of the important features of this steel is the tempering behaviour, and particularly the difference between the martensitic hardness level and the hardness which can be obtained after tempering at say 650 deg. C. A typical tempering curve is shown in Fig. 1, demonstrating the relatively poor tempering resistance of this steel. The martensitic hardness of 430 VPN is reduced to 240 VPN after tempering for 1 hour at 650 deg. C. Typical mechanical properties obtained over a range of tempering temperatures are given in Table 1, and it will be seen that it is difficult to obtain much above 45 t.s.i. after tempering at 650 deg. C. For aircraft applications where weight is important it is necessary to increase this tensile strength considerably. In addition, in steam power plant the fatigue strength of lower pressure turbine blades is becoming more important as the blades are made longer. Since the limiting fatigue stress is generally related to tensile strength this also means that increased tensile properties are desirable from a 12 per cent Cr steel. An example of one of these long low pressure turbine blades is shown in Fig. 2.

It should be emphasised at this stage that any attempt to produce a higher tensile strength by lowering the tempering temperature is not recommended, since the microstructure produced by a tempering temperature of say 550 deg. C. is unfavourable from many aspects, including the susceptibility to stress corrosion. It should be noted, however, that the combination of properties which can be obtained using low tempering temperatures (i.e., from 300 to 450 deg. C.) are quite reasonable, and further comment will be given on this point when Jethete M.152 is discussed. The disadvantages of a low C, 12 per cent Cr steel can therefore be summarised as relatively low tensile strength, fatigue resistance and impact properties after a tempering treatment which is necessary to produce good ductility and corrosion resistance.

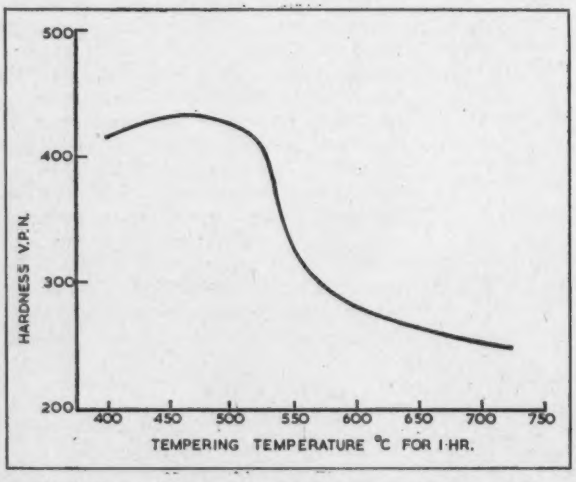


Fig. 1. Tempering curve for 0·1 per cent C, 12 per cent Cr steel.

* Dr. Irvine is deputy research manager, and Mr. Murray is head of the applied metallurgy section, of the research and development department of the United Steel Companies Ltd.

Jethete M.151

Jethete M.151 is a low C 12 per cent Cr steel which has been alloyed with nickel, manganese, molybdenum and vanadium to produce increased tempering resistance whilst retaining good weldability and formability. The improved tempering resistance means that after tempering at 650 deg. C. the tensile properties are considerably increased over those of the simple 12 per cent Cr steel, and there is also a notable improvement in the high temperature properties.

A very complete study has been made of the effect of alloying elements on the tempering resistance of 12 per cent Cr steels, and this information will be published separately. From this work, however, it was possible to select the alloying elements to produce the required increase in tempering resistance, whilst maintaining a balanced structure. From the point of view of Jethete M.151 what was required was an increase in the tempering resistance associated with good formability. The major requirement for good forming properties is that the steel can be softened easily, and following fabrication can then be re-hardened without the use of excessively high solution temperatures. From the background work on the effect of alloying elements on tempering resistance it was known that molybdenum, vanadium, niobium and titanium all increased the tempering resistance considerably. Of these, Mo and V were selected, since these meet the requirement for formability. If Nb and Ti are used then stable carbides are formed during the softening treatment which are extremely difficult to take back into solution in a subsequent hardening process. In contrast, the carbides which are formed when Mo and V are present can be readily dissolved at 1,050 deg. C. Since Mo and V are ferrite-forming they must be balanced by austenite-forming elements, and to meet the formability requirement for Jethete M.151 a combination of Ni and Mn is used. Whilst Ni is more effective as an austenite-forming element it depresses the Ac_1 temperature appreciably, and as explained previously this hinders the softening operation. With the combination of Ni and Mn that is used in Jethete M.151, however, the AC_1 temperature is at approximately 750 deg. C. A typical composition for Jethete M.151 is as follows: 0·10 C; 1·50 Mn; 0·30 Si (max.); 1·3 Ni; 12·0 Cr; 0·60 Mo, and 0·35 per cent V.

The tempering curve for Jethete M.151 is given in Fig. 4. If this is compared with that of the 0·1 C, 12 per cent Cr steel in Fig. 1, it will be seen that Jethete M.151 has appreciably increased tempering resistance, most marked in the tempering range 600 to 700 deg. C. Isothermal tempering curves are given in Fig. 5, and these show that, whilst the hardness is maintained very well with extended tempering at 600 and 650 deg. C., softening readily occurs after tempering at 700 deg. C. In fact, softening proceeds more rapidly if the steel is in the cold worked condition prior to tempering, so this means that there is little difficulty in softening sheet prior to forming and it is even easier to soften a steel during pressing by interstage annealing.

An indication of the forming properties of this steel can be seen in the figures which are given below. In this case a deep dished pressing was made in one pressing operation. Typical examples of deep pressings made in this steel are shown in Fig. 3. Tensile properties are given for the softened condition prior to pressing and at different stages during pressing, softening and subsequent hardening and tempering operations. It will be seen that the proof stress is low and the elongation high in the softened condition prior to pressing, and similar properties can be readily obtained after the annealing operation. Full properties are restored by the solution treatment, and the final tempering operation gives the required properties for Jethete M.151 with a high tensile strength and 0·2 per cent proof stress associated with good ductility.

Condition	*Tensile Strength t.s.i.*	*0·2% P.S. (t.s.i.)*	*% Elong. on 2 in.*
As received (700°C. 12 hr.)	44	34	21
Cold pressed	59	49	6
Softened 750°C. 1 hr.	44	24	18
Solution treated 1050°C. a.c.	85	60	8
Tempered 675°C. 4 hr.	54	48	14

Mechanical properties were determined over a range of tempering temperatures, and these are given in Table 2 and summarised in Fig. 6. It will be seen that the tensile strength follows a very similar curve to the hardness on tempering, and that the mechanical properties which can be obtained after tempering at 650 deg. C. are appreciably increased compared with the low C, 12 per cent base composition. The change in the room temperature impact value is also included in Fig. 6, and it will be seen that reasonable impact properties are obtained either with low tempering temperatures (up to 450 deg. C.) or high tempering temperatures (650 to 700 deg. C.) Low impact properties are obtained with intermediate tempering temperatures, which is further confirmation of the recommendation that this tempering

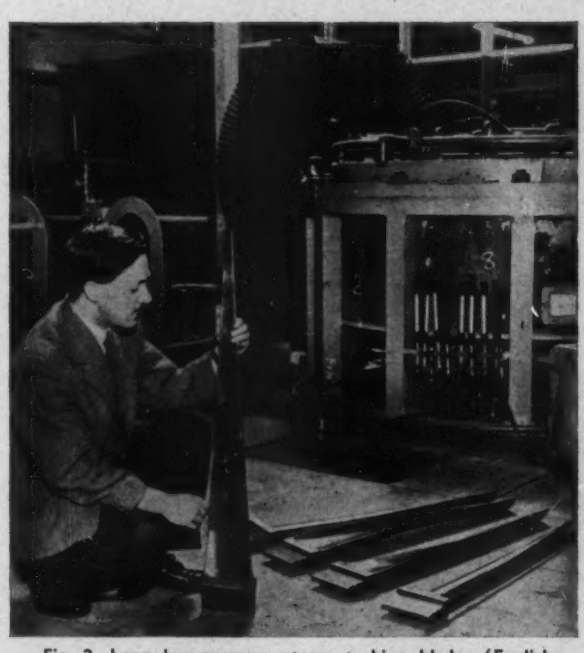
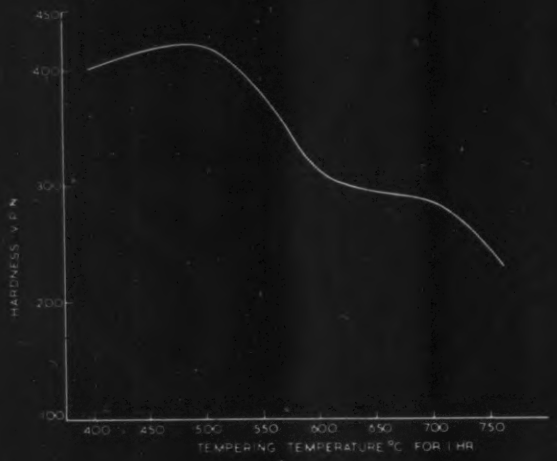
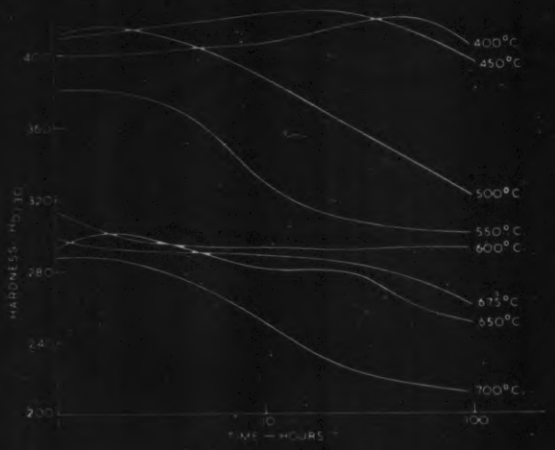
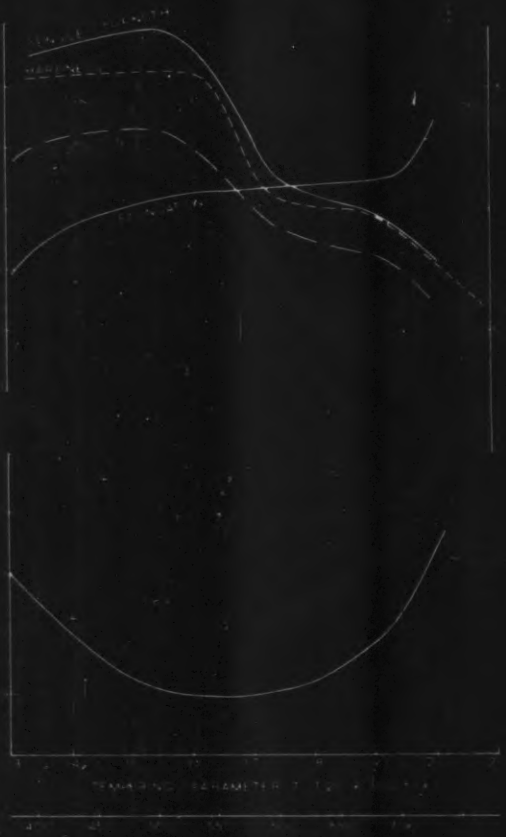


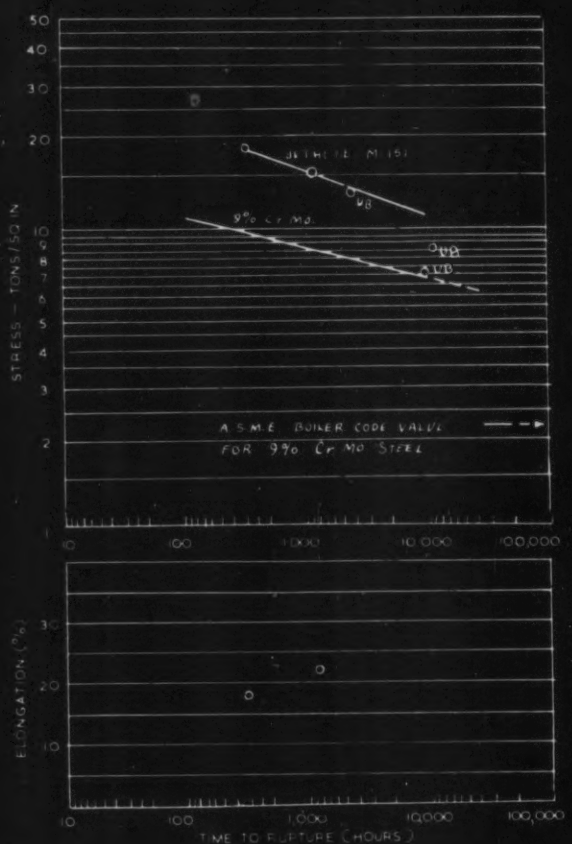
Fig. 2. Long low-pressure steam turbine blades (English Electric Co. Ltd.).

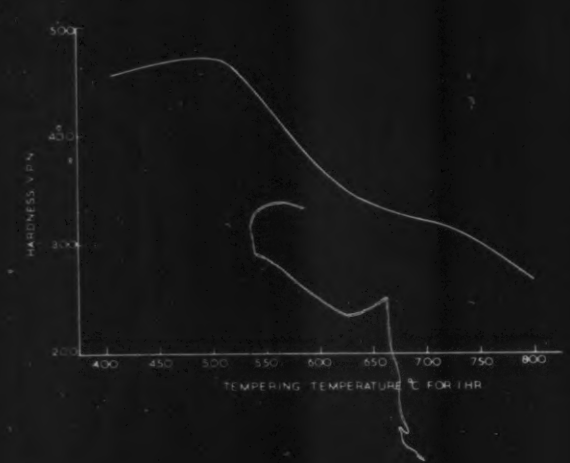
Fig. 3. Pressings made in Jethete M.151.

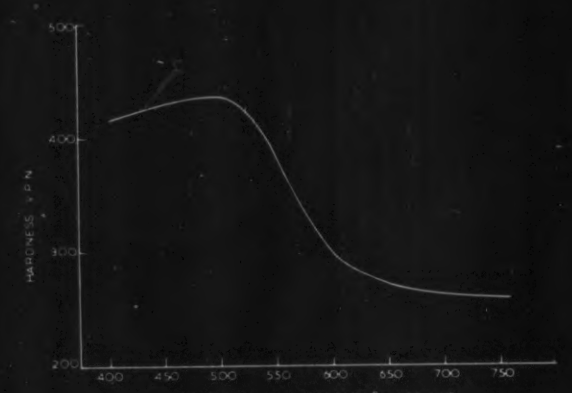

HARDNESS V.P.N.
TEMPERING TEMPERATURE °C FOR 1 HR

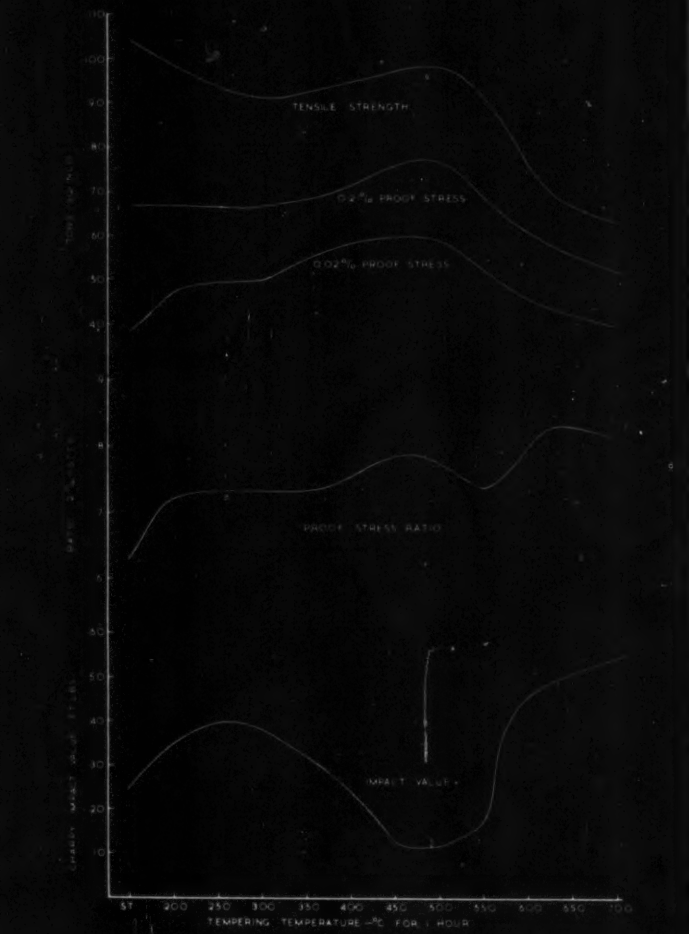

400°C
450°C
500°C
550°C
600°C
650°C
700°C
HARDNESS Hv 30
TIME — HOURS




STRESS — TONS/SQ IN
9% Cr Mo.
UB
A.S.M.E. BOILER CODE VALUES
FOR 9% Cr Mo STEEL
ELONGATION (%)
TIME TO RUPTURE (HOURS)


HARDNESS V.P.N.
TEMPERING TEMPERATURE °C FOR 1 HR


HARDNESS V.P.N.
TEMPERING TEMPERATURE °C FOR 1 HR



range should be avoided.

For many of the applications considered for this steel the operating temperatures are from 200 to 400 deg. C. There is interest therefore in the way in which the tensile properties change at elevated temperatures. Typical properties are given in Table 3, and it will be seen that the tensile strength and proof stress values are reasonably maintained up to 500 deg. C. Another important property is fatigue resistance, both at room temperature and elevated temperatures. Typical fatigue properties are given below, from which it can be seen that quite satisfactory fatigue strength is obtained up to 500 deg. C.

Tempering Temperature	*Test Temp. °C.*	*Tensile Strength (t.s.i.)*	*Limiting Fatigue Stress (±t.s.i.)*	*Fatigue Ratio*
1050°C. a.c.				
+ 650°C. 1 hr.	R.T.	60·8	32·5	0·53
	400	50·5	25·0	0·50
	500	36·9	20·5	0·55
1050°C. a.c.				
+ 675°C. 4 hr.	R.T.	57·1	31·0	0·54
	400	45·4	25·5	0·56

For aircraft engine applications the most important properties are the creep and rupture strength at temperatures between 400 and 500 deg. C. A summary of the high temperature properties is given below.

Temperature	400°C.	500°C.	600°C.
Stress (t.s.i.) to give 0·1% total plastic strain in:			
100 hr.	26·0	14·0	4·0
300 hr.	25·0	12·7	3·2
Stress (t.s.i.) for rupture in			
100 hr.	41·0	26·2	10·3

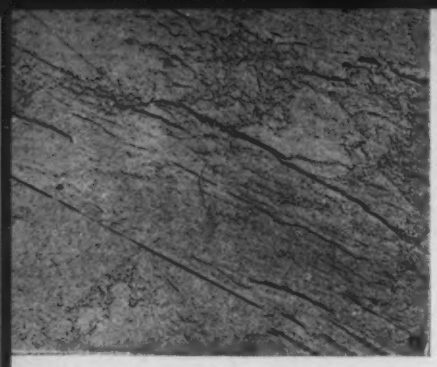
There is growing interest in 12 per cent steels for steam power plant for superheater and re-heat tubes, since they fill an intermediate position between low alloy and austenitic stainless steels. For this application long time rupture strength is the important criterion, and results are available to show how Jethete M.151 compares with 9 Cr, 1 per cent Mo, which is currently used and which has an A.S.M.E. Boiler Code rating. It will be seen from Fig. 7 that Jethete M.151 has an appreciably higher rupture strength at 550 deg. C., which is the temperature at which such a steel is likely to be used.

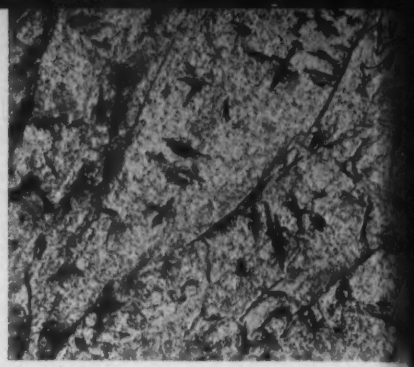
Because of the features which have been described above it is likely that Jethete M.151 will have its major applications in aircraft engines and steam power plant, and that it will be used principally in sheet and tube form because it is specially suitable for forming.

Jethete M.152

One limitation of Jethete M.151 is the impact resistance which is obtained after the normal tempering temperatures used, namely 650 deg. C. Whilst this is adequate for many applications, particularly where the operating temperature is above room temperature, the steel cannot be recommended for sub-zero applications. A detailed study has been completed on the factors affecting the impact properties of 12 per cent Cr steels, from which a suitable composition range has been evolved to give appreciably improved properties. A typical example of such a composition is as follows: 0·12 C; 0·70 Mn; 0·30 Si (max.); 2·40 Ni; 12·0 Cr; 1·70 Mo, and 0·35 per cent V.

The major difference in composition is that there is a higher Mo content, which is in turn balanced by a higher Ni content. It has been found that a minimum Mo content of 1·25 per cent is essential to achieve good impact properties. The tempering curve of Jethete M.152 is shown in Fig.





8, and it will be seen that, whilst this is of a similar form to Jethete M.151, there is a slight improvement in tempering resistance due to the higher Mo content. This means that it is more difficult to soften the steel, and in fact it is difficult to get much below 280 VPN with any reasonable softening treatment. The high Ni content has the effect of depressing the Ac_1 temperature so that it is not possible to use a softening temperature much above 700 deg. C. In spite of the high hardness of this steel in the softened condition, it has been found possible to fabricate sheet by cold pressing operations.

Typical mechanical properties obtained over a range of tempering temperatures are given in Table 4 and shown in Fig. 10. It will be seen that the tensile strength follows the hardness curve very closely, and the improved tempering resistance means that it is now possible to obtain a tensile strength of approximately 65 t.s.i. after tempering at 650 deg. C. for 1 hr. The proof stress values are high, and a ratio of 0·2 per cent p.s./t.s. of approximately 0·8 can be obtained in the tempering range 600–700 deg. C. The room temperature impact values are also included in Fig. 10, and when these are compared with those shown in Fig. 6 it will be appreciated how much Jethete M.152 is better than Jethete M.151 in this respect. There is a similar change in the impact level with tempering temperatures, so that high impact values are obtained with low and high tempering temperatures and poor impact properties obtained with tempering between 450 and 550 deg. C. More information can be obtained from a consideration of the impact transition curves, and these are shown in Fig. 11. It will be seen that low transition temperatures below 0 deg. C. are obtained with tempering temperatures between 200 and 400 deg. C. and between 600 and 700 deg. C. It is only the tempering temperatures between 450 and 550 deg. C. which produce an impact transition temperature above room temperature.

Jethete M.152 has many high temperature applications for which information about the high temperature tensile strength is useful. Typical mechanical properties obtained at test temperatures up to 600 deg. C. are given in Table 5. It will be seen that the strength is reasonably maintained up to 500 deg. C., following which there is a more rapid decrease. For many applications fatigue resistance is also important, and properties are available for Jethete M.152 both at room temperature and temperatures up to 500 deg. C. These properties were determined on the sheet in two tempered conditions, namely tempered 300 deg. C. for 1 hr., and tempered 650 deg. C. for 1 hr.

Heat Treatment	*Test Temp. (°C.)*	*Tensile Strength (t.s.i.)*	*Limiting Fatigue Stress ± t.s.i. (10×10^8 cycles)*	*Fatigue Ratio*
T 300°C. 1 hr.	R.T.	91·6	45·0	0·49
	200	90·3	40·5	0·45
T 650°C. 1 hr.	R.T.	67·3	37·5	0·56
	200	60·5	36·5	0·60
	400	55·0	30·0	0·54
	500	45·9	24·0	0·52

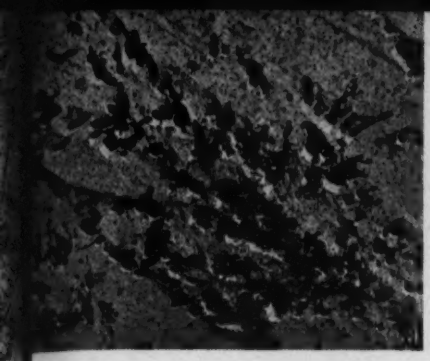
It is considered that these fatigue properties are very satisfactory, particularly after tempering at 650 deg. C., which will be the most widely used condition. The ability of this

Table 1. Mechanical properties of low-C 12 per cent Cr steel. (Analysis: C 0·10; Mn 0·74; Si 0·22, and Cr 12·42 per cent)

Tempering Treatment	Solution treated	450°C. 1 hr.	500°C. 4 hr.	550°C. 1 hr.	600°C. 4 hr.	700°C. 1 hr.	750°C. 100 hr.
Tensile strength (t.s.i.)	89·6	93·3	88·8	68·5	52·9	47·7	36·2
Proof stress (t.s.i.) for							
0·2 extension %	61·5	55·0	65·4	59·6	42·3	36·2	22·4
0·1 "	53·6	46·8	58·0	56·6	40·4	35·3	22·2
0·05 "	45·8	40·6	50·0	53·2	39·2	34·0	21·8
0·02 "	36·4	34·2	42·0	49·2	37·0	32·3	21·3
Elongation on $4\sqrt{A}$ (%)	15·8	11·5	18·0	20·2	23·8	28·3	38·8
Reduction of Area (%)	42·0	19·8	46·5	50·6	57·2	60·3	72·3

Table 2. Effect of tempering on the mechanical properties of Jethete M.151. (Condition: solution treated 1050°C., a.c. and tempered; specimens machined from blanks $7\frac{1}{2} \times 1\frac{5}{8} \times 0{\cdot}064$ in.)

Tempering temperature	Solution Treated	400°C. 1 hr.	500°C. 1 hr.	600°C. 1 hr.	600°C. 4 hr.	650°C. 1 hr.	650°C. 4 hr.	675°C. 4 hr.	700°C. 1 hr.	700°C. 4 hr.
Tensile strength (t.s.i.)	91·0	85·6	89·9	64·5	62·4	60·8	59·7	57·1	56·5	51·3
Proof stress (t.s.i.) for										
0·20 extension %	66·5	70·5	73·1	56·7	55·3	53·6	52·7	50·3	49·8	43·8
0·10 "	53·5	67·5	68·2	54·7	53·8	52·0	51·5	48·9	48·7	42·7
0·05 "	41·3	65·7	64·4	52·1	51·7	49·6	50·0	47·6	47·1	41·8
0·02 "	28·4	62·1	58·1	49·3	49·4	46·2	47·7	45·5	45·0	40·2
Elongation on 2 in. (%)	7·1	8·5	10·5	10·8	11·6	10·4	11·6	11·3	11·5	13·9
Ratio: 0·2% p.s./t.s.	0·73	0·82	0·81	0·88	0·89	0·88	0·88	0·88	0·88	0·85



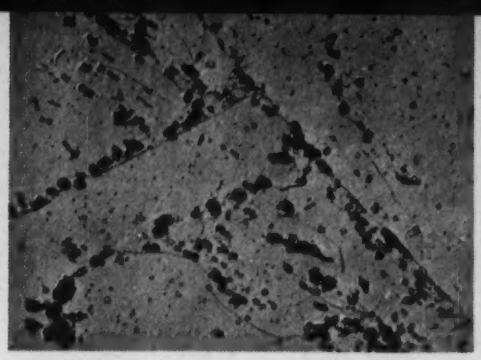


Fig. 12 (a)-(e). Electron microphotographs of Jethete M.152:
(a) solution treated
(b) tempered 1 hr. at 300 deg. C.
(c) tempered 10 hr. at 500 deg. C.
(d) tempered 1 hr. at 650 deg. C.
(e) tempered 100 hr. at 700 deg. C.

steel to retain high tensile strength at temperatures up to 500 deg. C. is also reflected in the high fatigue strength at this temperature.

For aircraft engine applications short-time high temperature properties are required, and these are available at temperatures between 450 and 600 deg. C. These properties were determined on the steel after tempering at 650 deg. C. for 1 hr.

Temperature	*450°C.*	*500°C.*	*600°C.*
Stress (t.s.i.) to give 0·1% total plastic strain in			
100 hr.	29·6	20·4	6·7
300 hr.	28·2	18·0	4·7
Stress (t.s.i.) to give rupture in			
100 hr.		37·4	
300 hr.		35·0	

It will be seen that these properties are superior to those obtained with Jethete M.151, and its superiority has resulted in Jethete M.152 being substituted for Jethete M.151 in certain aircraft engine applications.

It is claimed that these Jethete steels are weldable, and information is given for Jethete M.152 as being typical of the series. In fact, Jethete, M.151 and M.153 are slightly easier to weld than Jethete M.152 because the martensitic hardness level is slightly lower. Although the martensitic hardness level of Jethete M.152 is approximately 480 VPN, it is necessary to remember that the steel only has 0·1 per cent C, and consequently there is little stress produced when martensite is formed. It is for this reason that little trouble is experienced with hard zone cracking.

WELDING—Tests have been carried out to demonstrate the welding characteristics of thin and thick sheet. To examine the properties of the parent metal, Argonarc welding was used with the parent metal as filler wire.

¼-in. thick sheet

Condition:	*Hardness survey V.P.N.* *Tempered Zone*	*Hardened Zone*	*Weld Metal*
Welded	340	520	460
Welded and tempered	317	368	358

Condition:	*Tensile Properties* Welded and tempered 650°C. 1 hr.				
Test temp. (°C.)	*R.T.*	*200*	*300*	*400*	*500*
Tensile strength (t.s.i.)	66·7	57·4	54·6	53·7	46·2
Yield point (t.s.i.)	60·6	—	—	—	—
Elong. on 2 in. (%)	9·5	6·5	5·0	5·8	8·2
Position of failure	HAZ	HAZ	HAZ	HAZ	HAZ

Table 3. Jethete M.151, elevated temperature tests (solution treated at 1050°C. for 5 min. and tempered as indicated; test specimens machined from blanks 7½ × 1⅛ × 0·064 in.)

Test Temperature	200°C.	300°C.	400°C.	450°C.	500°C.	550°C.	600°C.
Tempering temperature	650°C. 1 hr.	650°C. 1 hr.	650°C. 1 hr.	650°C. 1 hr.	650°C. 1 hr.	650°C. 1 hr.	650°C. 1 hr.
Tensile strength (t.s.i.)	53·0	51·4	50·5	46·4	40·6	37·4	27·0
Proof stress (t.s.i.) for 0·20 extension %	46·3	46·3	41·7	40·0	31·6	27·0	18·8
0·10 "	44·6	44·5	38·8	38·0	28·3	24·4	16·2
0·05 "	42·5	42·2	35·3	35·1	25·7	20·8	13·4
Elongation on 2 in. (%)	6·3	7·1	6·4	7·0	10·0	13·4	11·3
Ratio: 0·2% p.s./t.s.	0·87	0·90	0·83	0·86	0·78	0·72	0·70

Table 4. Effect of tempering on the tensile properties of Jethete M.152

Tempering temperature for 1 hr. (°C.)	S.T.	200	300	350	400	450	500	550	600	625	650	700
Tensile strength (t.s.i.)	104·2	98·7	91·6	93·8	94·8	97·6	99·0	92·3	77·0	71·2	67·3	64·2
Proof stress (t.s.i.) for extension %												
0·2	65·9	72·6	66·5	69·2	72·5	77·1	77·8	68·8	61·3	60·0	55·8	52·6
0·1	55·6	63·6	58·6	62·4	65·8	71·2	71·4	63·0	56·6	56·8	52·3	48·9
0·05	47·8	56·7	54·0	58·8	62·3	66·2	67·0	58·0	52·0	53·0	48·6	45·1
0·02	38·4	48·4	50·1	57·2	59·0	61·1	60·8	53·2	44·9	47·4	42·6	40·2
Elongation % on $4\sqrt{A}$	18·1	19·6	20·6	19·4	21·4	21·4	21·4	21·4	23·9	24·0	20·0	22·0
Reduction of area (%)	47·2	47·2	57·6	60·8	57·6	57·6	57·6	57·6	57·6	57·6	54·4	57·6
Ratio 0·2% p.s./t.s.	0·63	0·73	0·73	0·73	0·76	0·79	0·78	0·74	0·80	0·84	0·83	0·82

1-*in. Plate*	*Tensile Properties*		
Condition:	Welded and tempered 650°C. 1 hr.		
Test temp. (°C.)	*R.T.*	*300*	*500*
Tensile strength (t.s.i.)	65·6	58·0	41·8
0·2% p.s. (t.s.i.)	54·7		
0·1% p.s. „	51·4		
0·05% p.s. „	48·2		
0·02% p.s. „	42·8		
Elong. % on 4 $\sqrt{A}$ (%)	16·1	14·8	21·4
Redn. of area (%)	54·4	51·2	67·2
Position of failure	HAZ	HAZ	HAZ

On order to assess the tendency for hard zone cracking, controlled thermal severity tests were carried out using a thermal severity number of 12 (producing conditions equivalent to butt welds in 1½-in. plate). Welds were carried out using pre-heats of 100 and 200 deg. C. In each case the welds were made with a constant heat input to the weld, and after welding the welds were allowed to stand for at least 24 hr. before sectioning. They were then examined microscopically for cracking with the following results:

Pre-heat

100°C. Slight cracking

200°C. No cracks

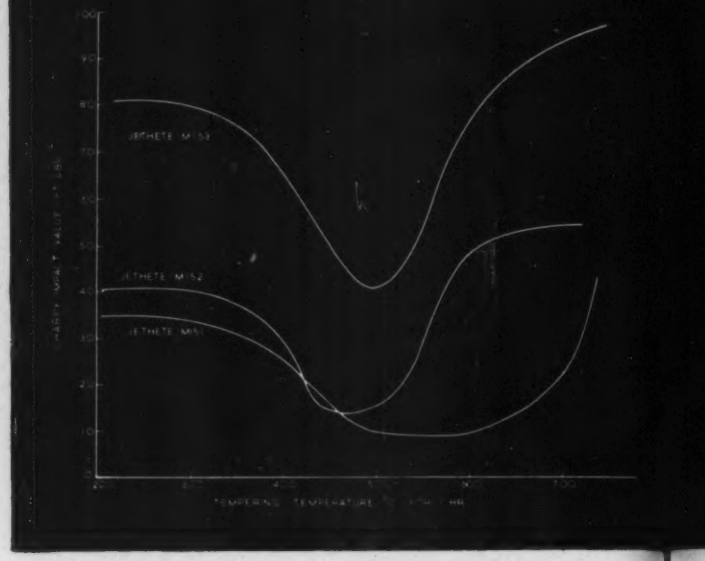
It is concluded that a pre-heat of 150–200 deg. C. is desirable when welding restrained joints in thick sections.

It will be appreciated that when thin sections are welded Argonarc welding will be used with the parent metal as filler. In thicker sections, if full strength is required through the welded joint, it is necessary to have weld metal of approximately the same composition as the parent metal. An experimental alloyed 12 per cent Cr electrode was used which gave the following weld metal analysis: 0·04 C; 0·4 Si; 0·36 Mn; 1·0 Ni; 10·8 Cr; 0·75 Mo, and 0·29 per cent V. To test the properties of this electrode welds were made in ½-in. thick Jethete M.152 sheet, and also an all-weld metal pad was tested.

Specimen	*½ in. thick sheet*			*Weld metal pad*
Heat treatment	Welded and tempered 650°C. 1 hr.			Tempered 650°C. 1 hr.
Test temp. (°C.)	*R.T.*	*300*	*500*	*R.T.*
Tensile strength (t.s.i.)	63·6	54·6	46·4	69·4
Proof stress (t.s.i.)				
0·2%	56·9			63·6
0·1%	54·4			61·4
0·05%	51·0			59·0
0·02%	46·8			55·2
Elong. on 2 in. (%)	5·0	4·4	5·5	6·6
Position of failure	WM	WM	WM	—

It will be seen that this electrode gives a weld which has the same strength as the parent metal, and satisfactory tensile properties are obtained both at room temperature and at elevated temperatures up to 500 deg. C.

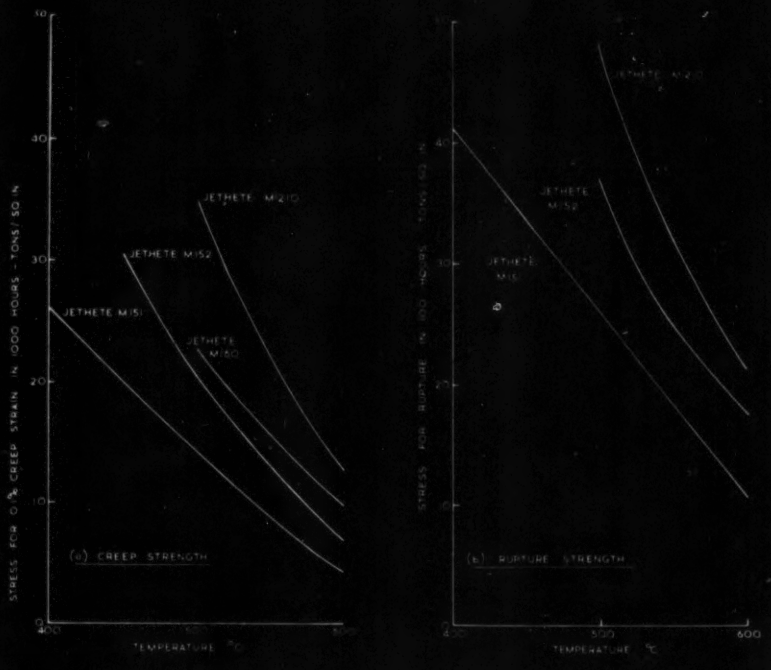
The general summary of the welding characteristics of Jethete M.152 is that it is possible to obtain satisfactory welding, both in sheet and also in sections up to at least 1 in. thick. There is no tendency to hard zone cracking in thin sections, but in thick sections with restrained joints it is preferable to use a pre-heat of 150–200 deg. C. The good tempering resistance of this steel means that softening is prevented in the heat-affected zone, so that tensile properties in welded joints are equivalent to those in the parent metal.



A detailed electron microscope study has been carried out on Jethete M.152, and this enables the relationship between microstructural features and mechanical properties to be illustrated. In the solution-treated condition the structure is of untempered martensite, and the photograph shows few definite features. The martensite plates are visible but there are no carbide particles within these martensite plates (Fig. 12(a)). With tempering at temperatures between 200 and 350 deg. C. there is a precipitation of Fe_3C plates within the martensite (Fig. 12(b)), and this precipitation of carbide results in a slight decrease in hardness. It also results in a reduction of internal stress, so that the mechanical properties are quite satisfactory with good tensile and proof stress values associated with a high level of ductility, impact and fatigue resistance. When the steel is tempered at temperatures between 450 and 550 deg. C. there is a fine matrix precipitate which has been identified as M_2X (Fig. 12(c)). This precipitate results in secondary hardening and causes a reduction in the impact resistance. When the tempering temperature is increased to 650 deg. C. this matrix precipitate overages and there is quite appreciable softening

Table 5. High temperature tensile properties of Jethete M.152 (heat treatment: 1050 deg. C., a.c. tempered 650°C. for 1 hr.)

Temperature of test	R.T.	200°C.	300°C.	400°C.	500°C.	600°C.
Tensile strength (t.s.i.)	67·3	60·5	58·6	55·0	45·9	32·9
Proof stress (t.s.i.) for extension % 0·2	55·8	50·8	53·0	45·9	38·2	22·6
0·1	52·3	48·1	51·4	42·2	34·7	19·6
0·05	48·6	44·6	48·6	39·4	31·7	17·0
0·02	42·6	40·4	40·5	35·5	25·9	13·0
Elongation % on $4\sqrt{A}$	20·0	—	15·7	18·7	29·0	55·4
Reduction of area (%)	54·4	57·6	40·0	56·0	67·2	82·9
Ratio: 0·2% p.s./t.s.	0·83	0·84	0·90	0·83	0·83	0·68



(Fig. 12(d)), but the reduction of the coherency strain associated with the secondary hardening process results in a marked improvement in the impact resistance. At this stage the hardness decreases to approximately 300 VPN, but extended tempering in the range 600–700 deg. C. does not cause much reduction in hardness. The fine matrix precipitate is relatively stable in this range, and can only be eliminated by increasing the tempering temperature to 700 deg. C. in relatively long periods. (Fig. 12(e)). This represents the softest condition that can be obtained in Jethete M.152.

It will be seen from the results which have been given that Jethete M.152 has an extremely good combination of strength, ductility, fatigue strength, impact resistance and creep and rupture strength, and it is recommended as the best all round high strength 12 per cent Cr structural stainless steel.

Jethete M.153

It has been shown that both Jethete M.151 and M.152, which are alloyed with molybdenum and vanadium, have appreciably improved tempering resistance compared with the base low carbon 12 per cent Cr steel. There are applications where the high strength of these steels is not required and where easier softening is an advantage. For these applications Jethete M.153 has been developed as an intermediate steel between the base low carbon 12 per cent Cr and Jethete M.152. A lower degree of tempering resistance is produced by using molybdenum alone as an alloying element. A typical composition of Jethete M.153 is: 0·10 C; 1·40 Mn; 0·30 Di (max.); 1·5 Ni; 12·0 Cr, and 1·30 per cent Mo.

The tempering curve is shown in Fig. 9, and it will be seen that this occupies an intermediate position between those of Jethete M.152 and the base 12 per cent Cr steel. The lower tensile strength coupled with the high molybdenum content means that extremely good impact properties can be obtained. Typical mechanical properties obtained over a range of tempering temperatures are given in Table 6, and a comparison of the impact values of the three Jethete steels is shown in Fig. 13. After tempering at 650 deg. C., and at a tensile strength of approximately 55 t.s.i., Jethete M.153 gives the best combination of strength, ductility and impact resistance.

Jethete M.160

Within the last few years some special 12 per cent Cr steels have been developed for aircraft engine compressor discs and blades. For these applications the most important

Table 6. Effect of tempering on the mechanical properties of Jethete M.153

Tempering treatment for 1 hr. (°C.)	200	250	300	350	400	450	500	550	600	650	675	700
Tensile strength, (t.s.i.)	85·71	81·61	81·75	83·84	82·60	85·71	85·01	71·0	57·43	52·61	52·90	59·55
Proof stress (t.s.i.) for extension %												
0·2	65·77	61·39	62·33	64·21	63·79	66·48	67·91	62·23	47·38	41·02	39·18	46·25
0·1	58·70	54·46	56·58	58·44	58·56	61·39	62·23	59·41	46·25	39·46	36·21	44·56
0·05	53·22	50·35	53·04	54·98	55·16	57·99	57·30	56·58	44·56	36·78	33·52	41·73
0·02	48·09	45·97	50·35	52·67	52·90	55·87	54·03	53·75	42·43	34·65	29·70	38·47
Elongation % on $4\sqrt{A}$	12·0	11·0	3·0	17·0	21·0	22·0	22·0	24·0	24·0	28·0	24·0	25·0
Reduction of area (%)	24·9	24·9	36·1	63·3	64·1	64·1	64·1	69·7	67·9	69·7	57·7	64·1
Izod impact (ft. lb.)	64	—	69	—	54	—	32	—	74	89	89	76
Ratio: 0·2% p.s./t.s.	0·768	0·752	0·763	0·766	0·772	0·775	0·8	0·876	0·825	0·78	0·742	0·777

criterion is the creep strength at temperatures between 400 and 500 deg. C., but this strength must be associated with a room temperature tensile strength of approximately 65 t.s.i. to allow easy machinability. To achieve high temperature strength, attention must be paid to the microstructure of the steel after tempering at 650 deg. C. There are two important aspects to be considered. The first is solid solution hardening (and the provision of hot hardness) in the matrix, and the second a fine stable carbide precipitate in the matrix. One example of this type of steel is Jethete M.160. In this case niobium is incorporated as an alloying element, and the necessity to use a high solution temperature does not present such a disadvantage in discs and blades as it would do in sheet and tube form. Consequently, there is no objection to using niobium for this type of steel. A typical analysis of Jethete M.160 is as follows: 0·14 C; 0·95 Mn; 0·30 Si (max.); 1·0 Ni; 12·0 Cr; 0·60 Mo; 0·30 V, and 0·25 per cent Nb.

One feature of the composition is that it has been chosen so that it gives a tensile strength of approximately 65 t.s.i. after tempering between 650 and 700 deg. C. With this room temperature tensile strength level there is then interest in the tensile and creep properties at elevated temperatures. These are summarised below.

Temperature	*20°C.*	*300°C.*	*400°C.*	*500°C.*	*600°C.*
Tensile strength (t.s.i.)	63·8	55·4	52·0	42·9	33·8
0·2% p.s. (t.s.i.)	54·0	47·4	43·4	34·3	29·6
0·1% p.s. „	52·0	45·3	40·2	31·5	27·5
0·05% p.s. „	49·5	42·8	36·8	28·8	25·2
0·02% p.s. „	45·6	39·5	31·8	23·8	19·8
% Elong.	22·5	18·4	22·4	21·9	22·5
Red. of Area (%)	56·4	51·2	64·8	63·6	64·0
Stress (t.s.i.) to give 0·1% total plastic strain in 100 hr.	—	—	26·0	14·0	4·0

It is possible to see how the creep strength of Jethete M.160 compares with that of Jethete M.151 and M.152 in Fig. 14 (*left*). It will be seen that Jethete M.160 offers some improvement compared with either of the other two steels.

Jethete M.210

Whilst Jethete M.160 was suitable for discs and blades, its properties begin to fall off at 500 deg. C. Consequently, when operating temperatures increased to 500 deg. C. in the compressor stage, improved materials were required. Jethete M. 210 is an example of this improved 12 per cent Cr steel, and exploits both aspects of solid solution hardening and matrix precipitation. Whilst it is possible to achieve tempering resistance with many combinations of alloying elements, certain of these elements are preferred for high temperature strength. For this reason molybdenum is used in an increased amount to provide the required tempering resistance, and cobalt is preferred to nickel to provide the balance in the microstructure. Also, boron is incorporated to add a new precipitation process to the matrix. The high temperature properties are summarised below.

Temperature	*500°C.*	*550°C.*	
Stress (t.s.i.) to give 0·1% total plastic strain in			
100 hr.	35·0	14·1	
300 hr.	31·8	11·0	
1000 hr.	25·8	—	
	500°C.	*550°C.*	*600°C.*
Stress (t.s.i.) to give rupture in			
100 hr.	48·0	32·0	21·0
300 hr.	47·5	30·0	18·0
1000 hr.	47·0	27·5	16·3
3000 hr.	46·0	25·0	13·0

The comparison between the high temperature properties of M.210 and the other Jethete steels can be seen in Fig. 14 (*two graphs*), from which it can be seen that Jethete M.210 represents a very marked improvement, particularly at 500 deg. C.

Comparison of Costs

It has been shown that it is possible to obtain different combinations of mechanical properties by altering the alloy additions to the base 12 per cent Cr steel. In order to put these steels into perspective it is now necessary to consider the price difference which these alloy variations make. A summary of the price of the Jethete steels, taking the low C 12 per cent Cr steel as 100, is given below.

Low C 12 per cent Cr steel	= 100
Jethete M.151	= 145
Jethete M.152	= 155
Jethete M.153	= 140
Jethete M.160	= 203
Jethete M.210	= 300

It is useful to consider the Jethete steels in two classifications. Jethete M.151, M.152 and M.153 can be considered as variations of a similar type of steel, namely a high strength structural steel. Jethete M.152 has the best all round combination of mechanical properties, whereas Jethete M.151 is a modification particularly suitable where cold forming is necessary, and Jethete M.153 is recommended where improved ductility and impact is required and a lower tensile strength level is acceptable. Considering the marked improvement in strength, the extra price of these Jethete steels compared to the base 12-per cent Cr steel can easily be justified.

The other classification includes Jethete M.160 and M.210, since these are steels developed specifically for short time high temperature properties. In this category the considerably higher price of Jethete M.210 can be justified because of the very marked improvement in the particular property required, namely creep strength at 500 deg. C.

Summary

From the information which has been given in this article it is possible to summarise the properties and applications of the Jethete steels as follows.

JETHETE M.151—This steel is used where the ability to soften for cold forming is most important. Its combination of oxidation resistance and strength means that it is particularly suitable for use at moderately elevated temperatures. Typical examples are aircraft engines (sheet for casings) and steam power plant (tubes for superheaters and re-heaters).

JETHETE M.152—This steel has the major advantage that extremely good impact properties are combined with a high level of tensile strength. It has similar aircraft engine applications to Jethete M.151, and is also used for large low pressure blades in steam turbines. It is recommended as the best high strength stainless steel for general application.

JETHETE M.153—This steel is preferred to Jethete M.152 where the maximum impact and ductility is required.

JETHETE M.160—This steel is particularly suitable for aircraft engine compressor discs and blades operating at temperatures between 400 and 450 deg. C.

JETHETE M.210—This steel has similar applications to Jethete M.160, but can be used at increased operating temperatures and has high short-time creep strength at 500 deg. C.

The authors wish to thank Mr. Saniter, Director of Research at the United Steel Companies Ltd., for permission to publish the results. They would also like to thank their colleages at Swinden Laboratories and at S. Fox & Co. Ltd. for their assistance in the compilation of the data.

PROBLEMS IN DESIGN

Problem No. 9 (July): Devise a mechanism which will cause a rotating input shaft to reciprocate angularly an output shaft, at right anges and approximately 2 in. below it, through an angle of 45 degrees. At the midpoint of the reciprocation the output shaft must have a dwell period of 5 degrees of rotation of the input shaft. One revolution of the input shaft must cause one complete reciprocation of the output shaft. Reciprocation shall be positive and no springs must be employed.

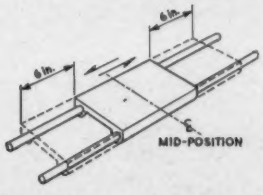
Readers sometimes write to say that our monthly problem is not formulated with sufficient precision, and that particulars of horsepower, torques and speeds, etc., should be given. There are several reasons why we do not do this. In the first place the amount of work involved in the adjudication of a large number of entries, each one of which sometimes represents a different approach, would be prohibitive. Secondly, we consider that a simple presentation without parameters is a stimulus to ingenuity. The latitude we give enables our readers to present a number of possible solutions, some suitable for one application, some for another. Faced with such a problem in an actual situation, it is simple to choose the entry best suited to conditions.

Designers and inventors are always storing away ideas in the back of their minds for use when the occasion arises. By presenting, month by month, simple problems commonly encountered in design, and publishing readers' entries, our object is to provide live material not usually found in text-books. We continue to be astonished by the variety and ingenuity of the entries we receive. We welcome problems from our readers, not only of the mainly mechanical kind we have presented recently, but also ones involving hydraulics, casting design, assembly, etc.

In setting the above problem we were afraid that the entries would be restricted to the barrel cam solution. Although the majority of the entries employed this principle, there were a number of interesting variants. In addition, as with the previous problem, there were the totally unexpected solutions. Having to decide between a simple schematic sketch of a sound mechanical principle and a beautifully drawn entry showing everything down to the last washer and split pin makes our job difficult.

PROBLEMS IN DESIGN

Here is this month's problem



In a packet filling machine, one feature comprises a reciprocating platen (diagrammatically illustrated above). This platen is required to reciprocate 6 in. to one side, then 6 in. to the other, with a variable dwell period at the mid-position. A 1,500-r.p.m. f.h.p. induction motor, continuously running, is to be used. Devise a suitable mechanism to achieve this.

Data: With no dwell period, the time for the complete cycle is approximately 2 seconds. The dwell period at the centre position (variable while stationary) is from 0-5 seconds, making a total cycle of 7 seconds.

Best solutions to "Problems in Design" are published and paid for. Send your solution for this month, with a drawing or diagram (in Indian ink and not more than 12×12 in., please!), to the Editor, "Problems in Design No. 12 (October)". Closing date November 14.

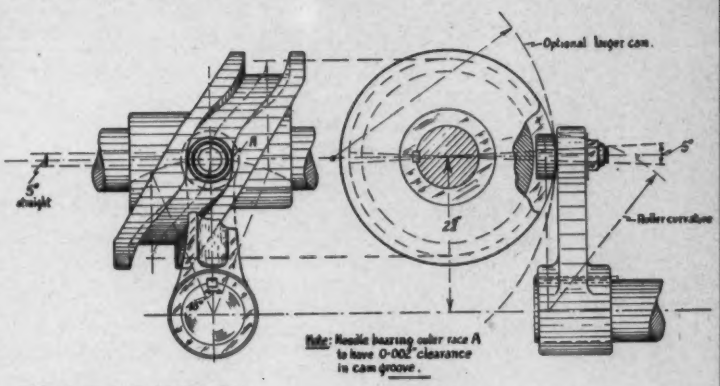


FIG. 1. V. J. G. HARDING

Taking the barrel cam entries first, **V. J. G. Harding's** entry (Fig. 1) is typical, and similar entries were received from M. L. S. Flint and D. A. Clarke. Mr. Harding employs a simple crank and roller design, the 5-degree dwell period being provided by the cam geometry. He has, however, shown the axis of the cam roller on the horizontal mid-plane of the barrel cam when in the vertical position. This means that, in the positions at the extremes of movement, the cam roller will be considerably below the mid-plane. This will cause the roller to move farther out of the cam groove than is necessary, and also provide an inferior contact between the roller and the cam faces. By arranging for the cam roller to be slightly above the mid-plane of the cam at the central position, and slightly below it in the two extreme positions, we consider that **A. Merry** (Fig. 2) has simplified the cam design. G. D. Cannon did the same thing. But why Mr. Merry has sealed his roller bearings *against* lubrication we find a little puzzling!

Other readers employing barrel cams were at pains to provide a linear movement of the cam roller, and so provide a better contact and simplified cam geometry. Unfortunately, this involves complication. **O. W. Bews** (Fig. 3) has mounted his cam follower on a sliding rack. This rack drives the output shaft, on which a pinion is mounted. The trouble with this arrangement is that sideways tilting of the cam roller is only constrained by the rack. J. Sinclair sent a similar entry. **D. Sleath** (Fig. 4) introduces three sliding elements to achieve the same thing, while **R. A. Hammersley** (Fig. 5) avoids these by using a Watt's approximate straight line motion. This we consider the better way.

The remaining entries, all different, depart completely from the foregoing, **W. M. Schatzberger** submitted two entries, one of which we reproduce (Fig. 8). Elegantly and simply presented, it represents that rare combination of good mechanical design, appreciation of the production cost of each component and ease of assembly.

R. A. Hammersley's second entry (Fig. 6) is very original, and we reproduce it (together with our own rough isometric sketch) solely on account of this quality. He has achieved, by means of chain drives and a slotted plate, all the requirements of the problem, including the dwell periods, without the use of cams. The slotted plate joins two identical three-cornered chain drives, and is reciprocated by means of a roller fixed to one link of a figure-of-eight chain drive. The dwell periods are produced by the roller moving for a short

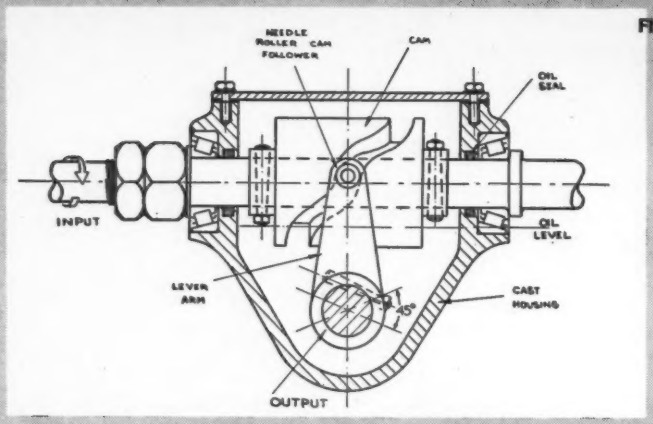


FIG. 2. A. MERRY

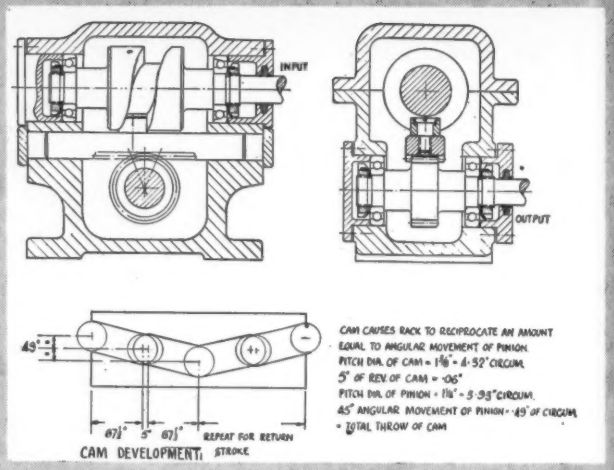

INPUT
OUTPUT
45°
67½° 5° 67½°
REPEAT FOR RETURN STROKE
CAM DEVELOPMENT
CAM CAUSES RACK TO RECIPROCATE AN AMOUNT EQUAL TO ANGULAR MOVEMENT OF PINION.
PITCH DIA. OF CAM = 1⅛" = 4·52" CIRCUM.
5° OF REV. OF CAM = ·06"
PITCH DIA. OF PINION = 1⅛" = 3·93" CIRCUM.
45° ANGULAR MOVEMENT OF PINION = 49" OF CIRCUM.
= TOTAL THROW OF CAM

FIG. 3. O. W. BEWS

distance in a horizontal direction in its passage round the figure-of-eight. A study of the right-hand view of Mr. Hammersley's drawing shows how this is achieved. Output is from the larger sprocket-toothed quadrant. Although the offset position of the roller relative to the chain is a clearly undesirable feature, and the mechanism is rather elaborate, it does nevertheless offer many possibilities. For example, by altering the size of the quadrant the amplitude of the angular reciprocation could be changed. Varying the relative positions of the guide wheels and sprockets also alters the dwell periods. This is a mechanism to remember!

Another most unusual and interesting solution comes from **W. Brown** (Fig. 7). He uses a constant diameter cam of special design to reciprocate a rack and pinion. He explains the cam geometry as follows: "The geometry of one such cam to a base radius of unity is shown in Fig. a, where "x" = half the stroke and ø = angle of dwell. Solution of triangle ABC gives "x", which for five degrees, is 0·689 in. It should be noted that the transition radius can be arbitrary and need not equal "x"... it depends on the permissible acceleration. Assuming ¼-in. base radius to suit a ½-in.-diameter shaft gives x = 0·258 in. with a stroke of 0·516 in. Accepting three teeth of 18 D.P. from twenty-four teeth requires a stroke of 0·5235 in. and the base radius becomes 0·3799 in."

This solution is a general one, as the rack could be positioned on either side of the slide, and either close to the input shaft axis or at some distance away. The shaft axes could be made to intersect if required. By cutting the rack on an angle, moreover, the shafts can be at any angle to each other, and by varying the cam and gearing a wide range of reciprocation and dwell is possible.

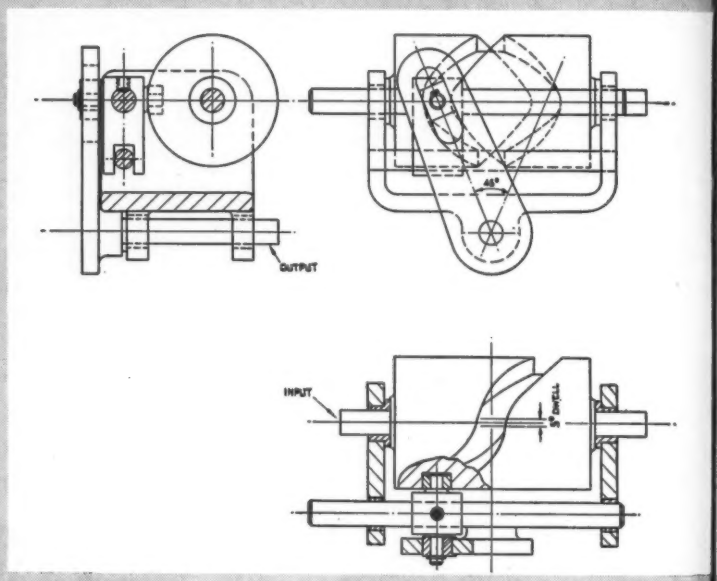


FIG. 4. D. SLEATH

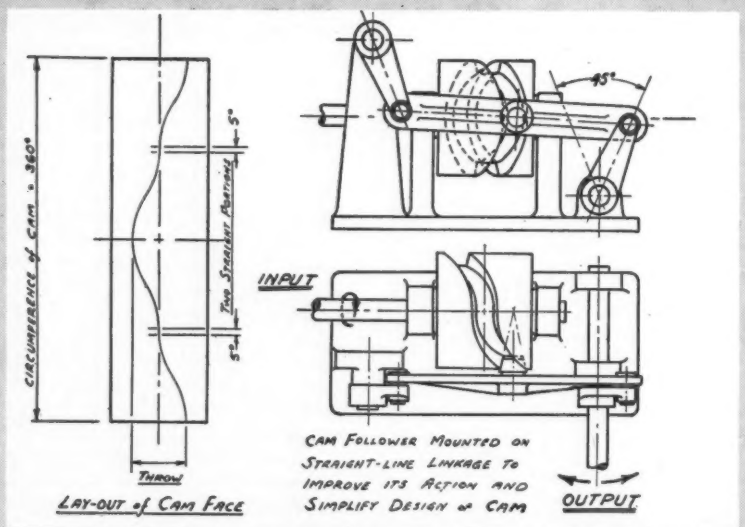


FIG. 5. R. A. HAMMERSLEY

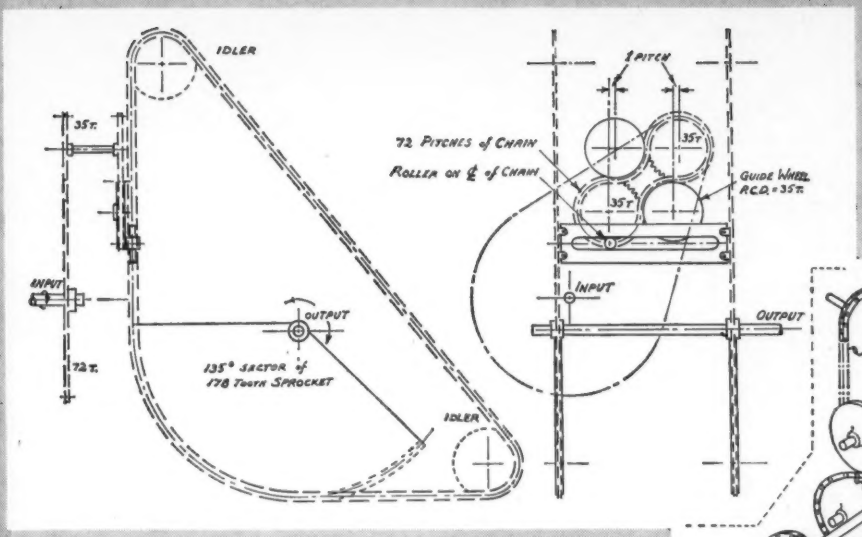


FIG. 6. R. A. HAMMERSLEY

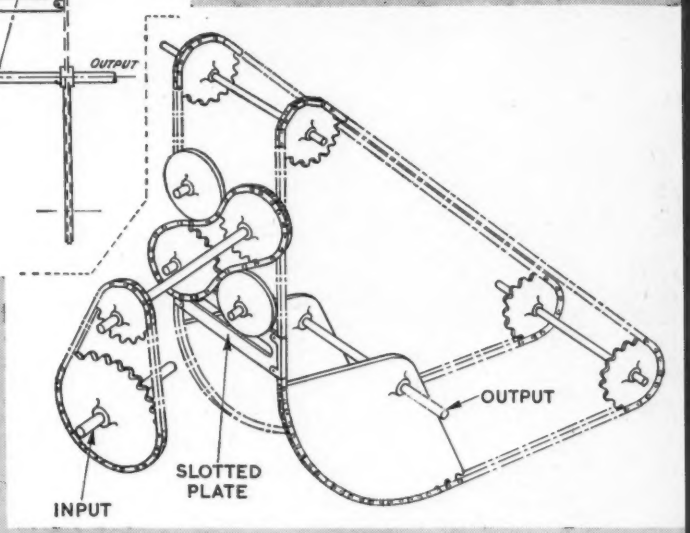


FIG. 7. W. BROWN

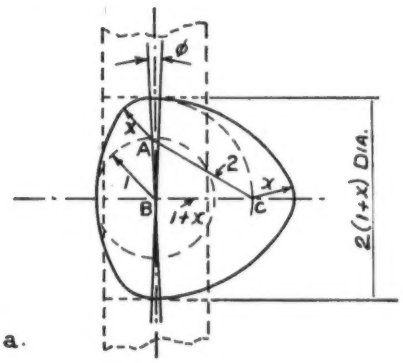


Fig. a.

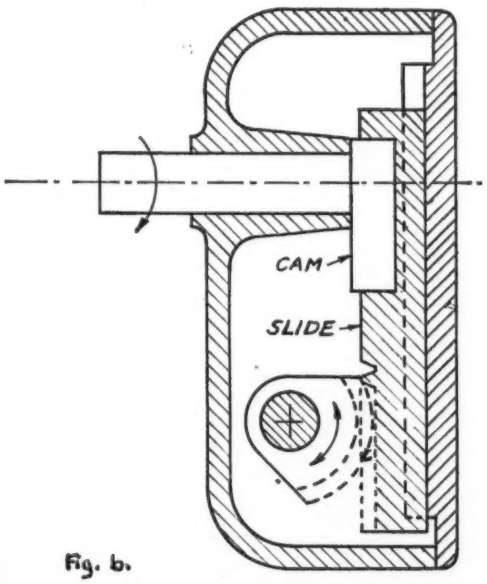
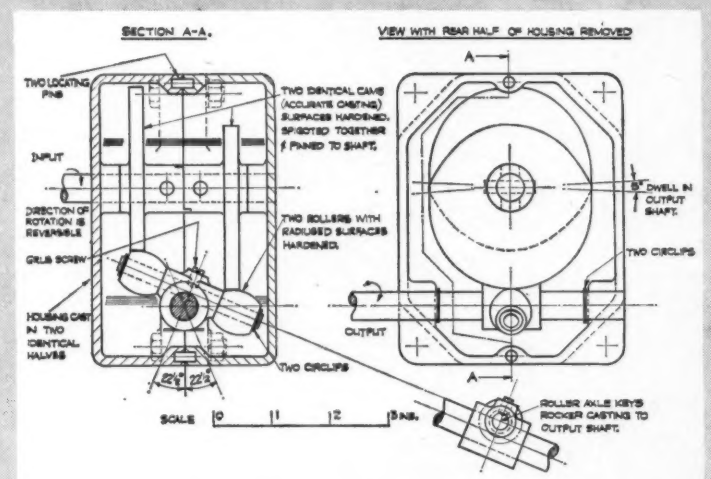


Fig. b.


SECTION A-A.
VIEW WITH REAR HALF OF HOUSING REMOVED
TWO LOCATING PINS
INPUT
DIRECTION OF ROTATION IS REVERSIBLE
GRUB SCREW
HOUSING CAST IN TWO IDENTICAL HALVES
TWO IDENTICAL CAMS (ACCURATE CASTING) SURFACES HARDENED, SPIGOTED TOGETHER & PINNED TO SHAFT.
TWO ROLLERS WITH RADIUSED SURFACES HARDENED.
TWO CIRCLIPS
OUTPUT
TWO CIRCLIPS
DWELL IN OUTPUT SHAFT.
ROLLER AXLE KEYS ROCKER CASTING TO OUTPUT SHAFT.
SCALE 0 1 2 3 INS.

NOTES: THIS DESIGN IS BASED ON THE ASSUMPTION THAT SPEED OF INPUT SHAFT AND MAX. TORQUE ON OUTPUT SHAFT ARE OF THE ORDER OF 60 R.P.M. AND 35 INS-LBS. RESPECTIVELY.

THE MECHANISM IS PACKED WITH LIGHT GREASE. SELF-LUBRICATING BEARING BUSHES MAY BE USED FOR INPUT AND OUTPUT SHAFTS.

ASSUMING TOOLING THROUGHOUT, CLEARANCE BETWEEN CAMS & ROLLERS CAN BE KEPT DOWN TO ABOUT $\frac{1}{32}$", CORRESPONDING TO A MOMENTARY DWELL AT EACH CHANGE OF DIRECTION OF OUTPUT SHAFT EQUIVALENT TO $\frac{1}{4}$° ROTATION OF INPUT SHAFT.

BOTH SHAFTS MAY BE ASSEMBLED ON THE BENCH BEFORE INSERTION INTO THE HOUSING.

FIG. 8. W. M. SCHATZBERGER

Seamless metallic bellows (Smiths Industrial Instruments Ltd.).

USE OF SEAMLESS METALLIC BELLOWS IN DESIGN

by LEO WALTER, A.M.I.Mech.E.

The seamless metallic bellows allows the designer to combine the characteristics of the helical spring and the semiflexible cylinder. It may be used as a simple spring, a pressure-sensing device, or as a means of accommodating variations in pipework

THE method of forming bellows in a single operation by hydraulic means has been responsible for a considerable increase in their application, owing to the great number of shapes and sizes made available in many different metals. Welded types of stainless steel bellows were used originally, until seamless bellows manufactured from special stainless material were introduced. The latest developments in manufacture cover large diameters and also rectangular shapes.

The two main uses in design are (a) with the bellows acting as a spring, or (b) as a vessel, which may be hermetically sealed. The great majority of designs combine these two characteristics, as will be seen later in this article. The combination of the characteristics of a helically coiled compression spring with those of a container gives the seamless metallic bellows unique qualities.

All reputable makers of seamless metallic bellows have available, for the designing engineer, technical literature which is meant to set out in detail the properties of their product. The main factors tabulated are: free length; number of convolutions; wall thickness of the material used; end connections available; effective area, and characteristics such as maximum deflection and spring rate per convolution. Manufacturers' catalogues also contain data for prediction of life, and examples of fixing end pieces to bellows.

In general, a bellows can be regarded as following the same kind of mechanical laws as a helical compression spring. There are, however much greater limitations in their use, such as those imposed by the straight line relation between load and travel (stroke). Preferably, bellows movement should be taken in compression, and the load kept within the elastic limit of the metal wall thickness being chosen to avoid a permanent set. The maximum allowable fluid pressure can be regarded as the highest pressure to which a bellows unit can be subjected at its normal free length without permanent deformation. Spring rates are usually quoted as lb./in. deflection of the spring. When used in connection with bellows subjected to either internal or external pressure, the value in p.s.i. is substituted for the load.

The effective area of a bellows is the area of a simple piston which will exert the same thrust as a bellows, and for all practical purposes may be expressed as follows:

$$\text{Effective area} = \frac{\pi (D^2 + d^2)}{8}$$

where D = outside diameter and d = inside diameter of the bellows.

It is very important to select the most suitable wall thickness to meet specified conditions of pressure, stroke and temperature, since the actual life of a bellows is more dependent upon correct thickness than on any other factor.

A laminated bellows of two, or even three plies, produced by placing one close-fitting tube inside another and then forming the corrugations, is often used for severe duties. A laminated unit of a given total wall thickness will withstand nearly the same pressure as a single ply bellows of equal wall, but the spring rate of the former is very much less and the maximum allowable stroke correspondingly greater. Assuming all plies are of equal thickness, the spring rate of the laminated bellows increases only in direct proportion to the number of plies, while the single-ply unit of the same total wall thickness shows a spring rate increase proportional approximately to the cube of that thickness.

In general, to avoid distortion by buckling, the length of a bellows should not be much greater than its diameter, although with relatively light loading this proportion can be increased somewhat. If the required flexibility cannot be realised with the recommended proportions, a much longer bellows may be used incorporating an internal or external guide. The actual outside diameter of a bellows should never be used for guiding purposes, an obvious point if the thinness of the bellows wall is considered.

Materials for Bellows

For seamless bellows, by far the best material from the point of view of manufacture and functioning is brass containing 80 per cent copper and 20 per cent zinc. This alloy is not readily liable to season cracking; in other words, when in the moderately cold-worked state suitable for bellows, it will not crack on standing in storage due to residual internal strains. Another material used is Alumbro (an alloy developed and patented by the British Non-Ferrous Metals Research Association), composed of 76 per cent copper, 22 per cent zinc and 2 per cent aluminium. This alloy has cold-working properties comparable with 80/20 brass, but is more resistant to corrosion. For certain applications, phosphor bronze, cupro-nickel, beryllium copper, Monel and low-carbon steel are used, such bellows usually being formed by rolling or spinning.

The resilience of a bellows, and its ability to withstand continuous movement, are dependent upon suitable and uniform physical properties of the materials as well as uniformity of wall thickness, the latter usually ranging from 0·004 to 0·010 in. For these reasons it is almost invariably the practice in manufacture to draw the required tubes individually from blanks cut from sheet material. Sound metal, free from inclusion of foreign matter, is essential, and particular care is necessary to produce a tube having good surface finish and correct grain structure. Wall thicknesses are normally maintained to $\pm 0{\cdot}00025$ in., and it may be noted that, even with these small tolerances, the flexibility of a bellows having, for example, a nominal wall thickness of 0·005 in. will vary by +16 and −13 per cent. This factor, together with other necessary tolerances on diameters, shape of convolutions and material properties, can cause variation of flexibility up to ± 20 per cent.

In the case of pressure-operated devices requiring accurate load/travel characteristics, the effect of variation in flexibility of the bellows, which as previously noted occurs even when wall thickness is maintained to very fine limits, can be minimised by the incorporation of a compression spring so that its spring rate is added to the bellows spring rate (see Fig. 3). By employing the most flexible bellows allowable, and a loading spring of stiffness as great as possible compared with that of the bellows, a greater consistency of load/travel characteristics is obtained over a large number of bellows units. The compression spring is provided with adjustment. It is advisable that the working fluid be contained within the cup and external to the bellows.

Applications

Fig. 4 shows diagrammatically a few basic applications of bellows and bellows assemblies:

(a) is an expansion chamber, movement being allowed for by increase or decrease in internal fluid pressure.

(b) allows a lever movement to be produced between two spaces, whereby the bellows provides a flexible joint.

(c) shows remote transmission of co-axial movement, without using pistons.

(d) is the basic design of a pressure element.

The construction of a thermostatic motor combined with a hydraulically-operated remote control employing bellows is shown in Fig. 5. Changes of temperature in the system cause movements of the bellows in the thermostat element, which through the rod actuate the bellows of the hydraulic transmission element, the displaced fluid flowing via the capillary tube to effect movement of the bellows in the power element.

Bellows shaft seals are widely used for refrigerator compressors, and are also applicable to such equipment as air compressors, pumps, and gearboxes. Fig. 6 shows a typical assembly. Another type employs a spring external to the bellows. A bronze with a high lead content is often used for the seal nose, but other materials having good bearing qualities may be selected, according to the operating service

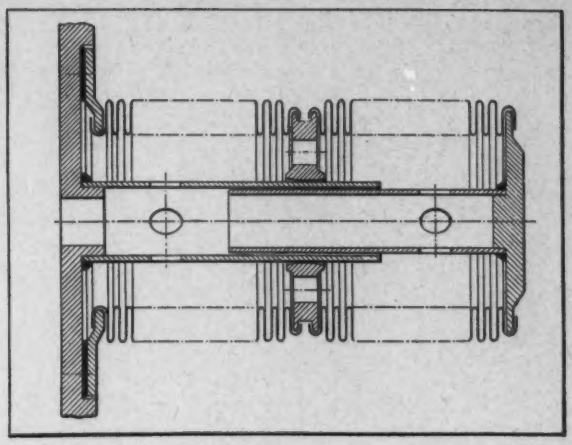


Fig. 1. Long-stroke assembly incorporating two seamless bellows with an internal guide.

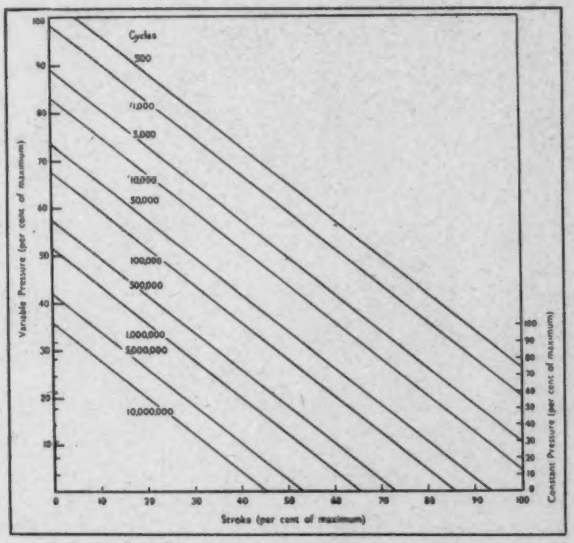


Fig. 2. "Hydroflex" life prediction chart for hydraulically formed seamless bellows (The Drayton Regulator & Instrument Co. Ltd.).

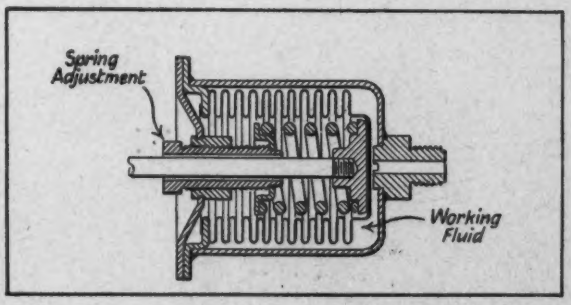


Fig. 3. Bellows assembly with adjustable spring loading.

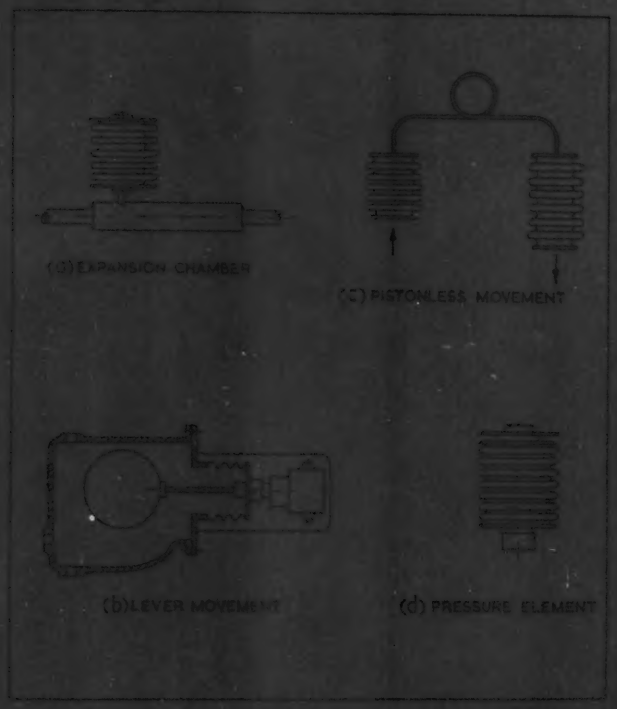


Fig. 4. Basic applications of bellows assemblies: (a) expansion chamber; (b) lever movement; (c) pistonless movement; and (d) pressure element.

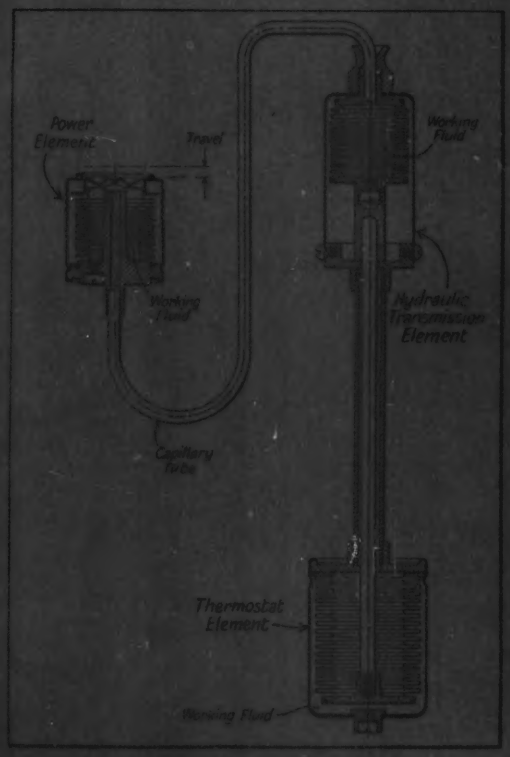


Fig. 5. Thermostatic motor combined with a hydraulically-operated remote-control element using metallic bellows.

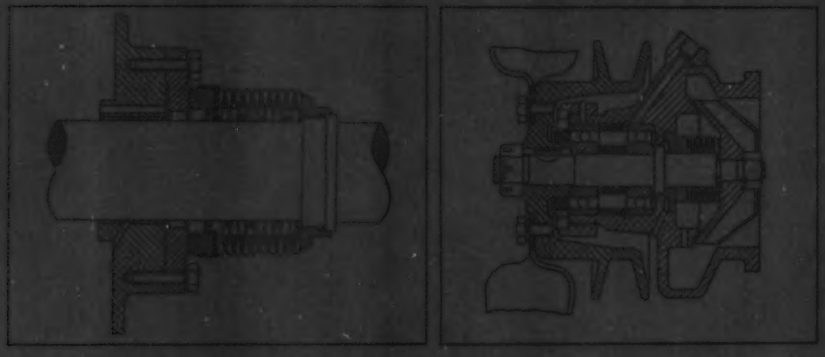


Fig. 6. Typical arrangements of the rotating type of packless shaft seal (Teddington Aircraft Controls Ltd. (Bellows Division)).

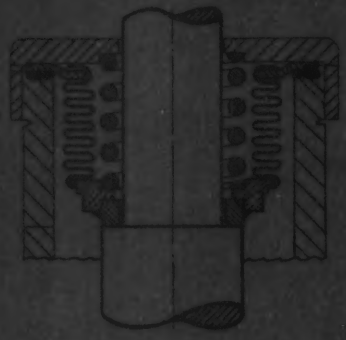
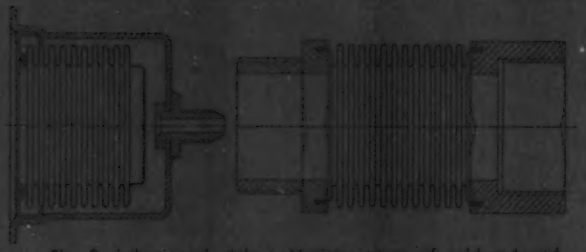


Fig. 7. Showing how a packless seal replaces a stuffing box for a rotating shaft.



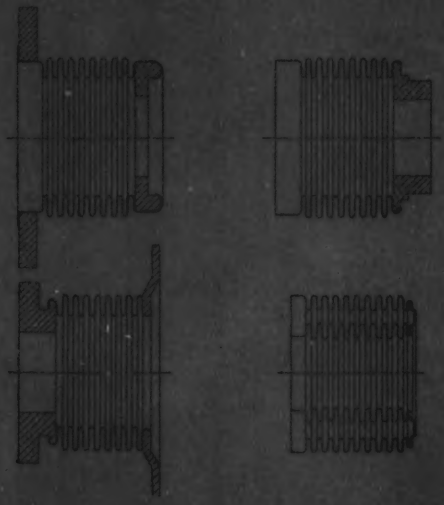


Fig. 8. (above and right). Various types of soldered end fittings.

conditions. The surface of the sealing ring and of the shaft shoulder must be finished to a high degree of squareness, flatness and smoothness to obtain an effective seal. Also, in these seals the end faces of the thrust spring are maintained parallel within 1 degree when the spring is compressed to its working length, so that the pressure is applied to the sealing ring in a direction closely parallel to and concentric with the axis. It is important that the shaft upon which the seal is used is not subject to vibration or deflection.

End Fittings and Assembly

Some of the methods of attaching end fittings to seamless bellows are shown in Fig. 8. It is notable that rolled and spun bellows, being made from open tubes, require fittings at each end, whereas hydraulically-formed bellows, which are made from drawn thimbles, already have one closed end which may be utilised. This end wall may be substantially thicker than the bellows portion, and can be dished to locate a spring or to have other parts attached to it.

End fittings are commonly soldered to the bellows, and on account of the thinness of the metal and the need for precautions against corrosive effects, should be spun or crimped to the heads or end enclosures to provide mechanical strength and relieve the soldered joint of load. The parts must be thoroughly cleaned, and flux should be used sparingly. Zinc chloride is a very satisfactory flux which ensures a sound joint, but it is absolutely essential that it be free from ammonium chloride. Although additions of the latter to zinc chloride cause the solder to flow more smoothly, it has a marked corrosive effect on the thin-walled brass or bronze bellows. Solder containing 50 per cent lead and 50 per cent tin gives good results, and is suitable where the apparatus is intended for use up to 150 deg. C. For temperatures up to 260 deg. C. a solder composed of 97·5 per cent lead and 2·5 per cent silver is recommended under certain conditions. Where an exceptionally strong joint is necessary, fittings can be attached by silver soldering, but unless great care is taken the necessary high temperature (650 to 820 deg. C.) may cause annealing of the bellows. It is preferable in such cases to use a mechanical joint.

The bellows assembly must be thoroughly washed after soldering to remove all traces of flux, and in cases where it is impracticable to clean the interior a flux comprising pure gum resin dissolved in alcohol, which requires no washing after soldering, should be used. The various makers of bellows strongly recommend that they be entrusted with this assembly work, to ensure satisfactory functioning of the bellows in service, it being their opinion that by far the majority of needless failures are due to faulty soldering.

Special Designs

PRESSURE SENSITIVE MECHANISMS—In these cases the first consideration is usually the effective "piston area" of the bellows. This is directly calculated by adding the area on the bellows outside diameter to the area on the inside diameter, and dividing by two. It is thus the mean area and *not* the area on the mean diameter. With one end of the bellows closed off, the bellows will behave like a piston and cylinder of this effective area, and react to internal pressure by extending, or to external pressure by being compressed. The latter arrangement is preferable, since a bellows works better, and has a longer stroke and a greater fatigue life if worked in compression. The spring rate of a bellows is not completely linear, and it is therefore usual to incorporate a spring in the mechanism having a much higher rate than the bellows and "swamping" the bellows rate to give effectively linear operation.

One arrangement uses precompression by the oppressed spring, so as to close the bellows onto a stop. In another arrangement the spring is mounted inside the bellows, and a stop prevents extension beyond the free length. An overrun stop sleeve is often fitted inside to act as a spring guide and limit stop.

CONNECTION TO WEIGH VESSELS—Sometimes it is necessary to make the pipework connected to a weigh vessel very flexible, so that its fluid contents can be weighed without disconnecting the pipework. It is usually best to use the hinging action of a bellows to provide lateral movement, since this minimises the spring reaction forces; if the system is pressurised the bellows can be hinged so as to restrain the pressure loads and prevent false readings.

Sometimes, when continuous weighing of pulverised solids must take place under pressure, the bellows units are placed above and below the vessel so that they move axially, and a correction factor is applied for the bellows spring rate. In such cases it is imperative that the bellows cuff connections be at the effective diameter. If not, there will be a reactive force coming from the pressure in the system operating on the annular difference in area between the bore and the effective area. This will stiffen the bellows and give progressively smaller and smaller readings as the pressure increases.

EXPANSION JOINTS—Simple low pressure applications in pipework or engine exhaust systems often have axial units. The full rated axial movement is obtained by using "cold draw", so that the installed length of the unit is greater than the free length cold. As the pipework expands with rising temperature, the bellows is returned to its free length, then compressed. For applications with liquefied gases at very low temperatures this situation is reversed, and the bellows units are fitted with "pre-compression" and expand as the pipework contracts on contact with the extremely cold fluid.

Double units provide also for lateral displacements, in which each bellow bends through a certain angle. It will be readily seen that the degree of malalignment is a direct function of the distance between the bellows. The length of a double unit may be limited by the weight of the centre tube, which is normally supported by the bellows.

For higher pressures, the double unit can be restrained over its length so that it cannot extend axially. By using links with spherical seating washers, or suitably hinged restraining links, the unit is still free to move laterally. For very high pressures each bellow becomes a single hinged unit, and the connecting pipe to make a double unit can be much longer, since its weight is borne by the hinge pins. Full compensation is obtained by using three hinged units, and this arrangement is often referred to as a "three pin arch". If movements are expected in more than one plane, the hinged units must become gimbal units so as to provide the necessary freedom.

SOME OF THE PRINCIPAL MANUFACTURERS AND SUPPLIERS OF METAL BELLOWS

Avica Equipment Ltd., 50 Pall Mall, London, S.W.1.

Francis Caird Ltd., Chesser Tubeworks, Sighthill, Edinburgh, Scotland.

Compoflex Co. Ltd., Paddockhall Road, Haywards Heath, Sussex.

Dewrance & Co. Ltd., 165 Great Dover Street, London, S.E.1.

Drayton Regulator & Instrument Co. Ltd., Horton Road, Yiewsley, West Drayton, Middlesex.

Smiths Industrial Instruments Ltd., Chronos Works, North Circular Road, London, N.W.2.

Teddington Aircraft Controls Ltd., Bellows Division, Ammanford, Carmarthenshire, Wales.

Thos. W. Ward Ltd., Brettenham House, Lancaster Place, Strand, London, W.C.2.

ZINC DIE CASTINGS
VERSUS
PLASTICS MOULDINGS

by G. FITZGERALD-LEE, F.R.Econ.S., M.I.E.I., A.R.Ae.S.

The versatility of plastics and zinc alloys is well known — this article sets out the fundamental advantages and disadvantages of each

NUMEROUS modern products can equally well be made as either zinc alloy die castings or plastics mouldings, but there are many cases in which either the zinc or the plastics product is better suited for its particular purpose. Some of the properties of the two materials are so different as to be hardly comparable at all, and the great variety of modern plastics materials tends to make generalisation unsafe for any particular product.

Plastics materials, which can be coloured by both dyes and pigments, emerge from the mould with an excellent finish. They have therefore a high ornamental value. For comparable decorative effect a superimposed finish is necessary for zinc alloy die castings. Plastics mouldings have a high resistance to chemical attack, not possessed by zinc alloy die castings unless specially protected.

The durability of plastics under prolonged outdoor conditions is not yet finally proven. Colouring from pigments is generally more permanent than that due to dyes, which unless carefully selected are not fast to light. Plastics are good electrical insulators, whereas zinc alloy die castings are good conductors. The mechanical properties of plastics mouldings are low as compared with those of zinc alloy die castings. Many thermoplastic mouldings soften at temperatures below the boiling point of water.

Plastics materials are conveniently sub-divided into two main types: thermosetting, which once moulded cannot be softened by heat, such as the phenol formaldehyde and urea formaldehyde plastics; and thermoplastics, which soften under the influence of heat, such as cellulose acetate, polystyrene, polymethylmethacrylate and polyethylene. The cost of the equipment required for moulding, and that of the moulding operation itself, is about the same as for die casting, but the price of plastics moulding powders—other than the general purpose thermosetting type—is relatively high, compared with that of zinc die casting alloys, and the incorporation of special fillers further adds to their cost. The general purpose thermosetting class is the cheapest, while cellulose acetate is the cheapest of the thermoplastics.

Methods of Manufacture

Methods of making zinc alloy die castings and plastics mouldings are generally similar and both permit rapid production of articles of complex design, with metal inserts and cored holes if required. The two zinc die casting alloys in greatest use are those covered by BS 1004 and referred to as Alloys A and B. Of these, Alloy A is used where good dimensional stability is essential, but its mechanical properties as cast are slightly lower than those of Alloy B. In cases where the maximum dimensional stability is required, Alloy A is given a short stabilising heat treatment of 6 hours at 100 deg. C., which renders it completely stable.

COMPRESSION MOULDING—The compression method of manufacture, by which the majority of plastics mouldings are produced, is chiefly confined to the thermosetting plastics. Moulding is effected under the influence of heat (150-200 deg. C.) and pressure (2,000-4,500 p.s.i.) in steel dies, which may require to be chromium plated for urea formaldehyde powders. Heavy presses are necessary, and by die casting standards the process is relatively slow, since between the opening and closing of the die a period must be allowed for the moulding to cure. For thin or comparatively small mouldings this period ranges from 15-90 seconds, and is longer in the case of thicker mouldings. It should, however, be noted that this slow production speed may be accelerated by the use of multiple moulds. Single

Petrol pump handle in zinc alloy (photo by Z.A.D.A.).

cavity dies are used for the largest mouldings, but dies may contain from four to six impressions for medium-sized mouldings, and up to 100 or more impressions for the very small mouldings. Speed of production is governed by the wall thickness of the mouldings. As many as 120 "lifts" per hour are attainable, and this figure is exceeded when extremely thin sections are moulded.

Compression moulding has an advantage in that the cheapest form of moulding powder is used, but more expensive and tougher thermosetting materials with fabric filler are also moulded in this way. This method may be used to produce relatively large mouldings, but as ordinarily operated, wall thickness is restricted by the low rate of heat transfer through the moulding, which entails some increase of curing time. The latest developments of high-frequency electric heating and transfer moulding overcome this limitation to some extent.

INJECTION MOULDING—The injection moulding process was at one time confined to thermoplastic materials, employing a process and equipment very similar to those used for die casting. The moulding powder, heated to a plastic condition at 150-230 deg. C., is injected under pressures of 7,800-31,500 p.s.i. into water-cooled dies, and the moulding when set is ejected complete with gate and runners. In America, mouldings of 2 lb. weight have been produced in this way. In this country mouldings have so far been limited to 1 lb., the volume of which is equivalent to 5 lb. of zinc alloy. The dies carry two to twenty-four or more impressions and the moulding cycle may range from 15 seconds to 2 minutes. Thicker sections cool more slowly and may set up shrinkage strains. An eight-impression die and a 20-second moulding cycle give about 1,400 small mouldings per hour. This rate of production of small mouldings is comparable with the speed of die casting. Recent developments have led to the injection moulding of thermosetting plastics. This method is probably quicker than the compression moulding of these materials, and may permit greater wall thicknesses.

DIE CASTING—Die casting has been aptly termed "the shortest distance between raw material and finished product." It is carried out by injecting molten metal under high pressure into a die. The machines used are of two types, namely: hot-chamber machines, in which the metal is injected into the die direct from a furnace forming an integral part of the machine; and cold chamber machines, in which the molten metal required for each "shot" is taken from a separate furnace and poured into position in front of the pressure plunger.

In both cases the casting solidifies at once and is produced at a speed unsurpassed by any other method of metal fabrication. Thus, for example, a medium-sized casting of 8 oz. can be produced by a single impression die at the rate of 200 an hour, and by an eight impression die at the rate of nearly 1,600 an hour. Extreme rates of production may be taken as represented on the one hand by the highly complex carburetter, say 18 an hour, and on the other by the zipp fastener elements cast directly on to the tape at 24,000 an hour. The upper limits of size and weight of zinc alloy die castings hitherto produced on a commercial scale may be judged from examples such as a motor car windscreen frame 47 in. long × 14 in. deep, and an American radiator grille of 36 lb. The largest grille produced in the U.K. weighs 17 lb. (for the Morris Oxford).

Table 1. Mechanical properties of plastics mouldings

Material	Specific gravity	Heat Distortion Temp. (°C.)	Water Absorption (% in 24 hr.)	Tensile strength (1000 p.s.i.)	Elongation (%)	Izod ft. lb. per in. length of notch
Methyl Methacrylate	1·18	50–75	0·3–0·4	4–9	1–15	0·1–0·2
Cellulose Acetate	1·3–1·6	50–90	1–3	2–10	8–30	0·3–2·1
Phenol formaldehyde						
wood filled	1·25–1·5	130–140	0·2–0·6	4–11	—	0·16–0·3
mineral filled	1·6–2·1	130–180	0·01–0·3	4–10	—	0·11–0·36
macerated fabric filled	1·4	120–140	0·5–2·5	6·5–8	—	0·4–2·4
Polystyrene.	1·06	72–82	Nil	5–9	2–5	0·17–0·25
Urea formaldehyde	1·45–1·5	130	1–2	9–12	—	0·2–0·25
Zinc Alloy A	6·6	—	—	41·5	12–14	63–9·8

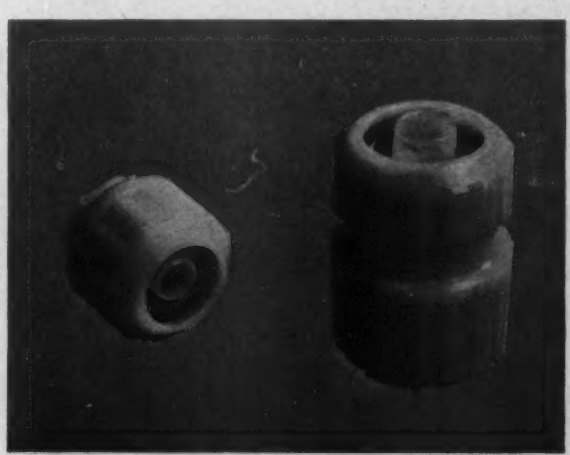
Properties

The properties of plastics mouldings vary within certain limits, according to type. The properties of a given plastics are also greatly influenced by the filler incorporated. Thus, in the case of phenol formaldehyde, considerably improved resistance to heat or shock may be obtained by the choice of an appropriate filler. Generally speaking, the properties of all plastics mouldings may be summarised as: light weight; high electrical resistance; low thermal conductivity; pleasing colour possibilities and good surface finish; good resistance to corrosion, although some plastics materials are affected by damp conditions; inability to withstand high temperatures, and relatively low mechanical properties.

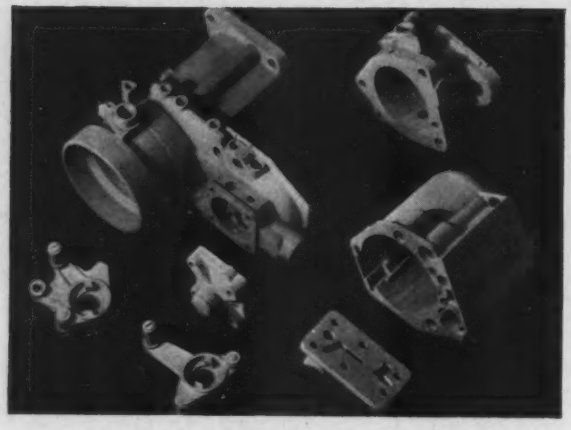
Good electrical insulating properties are an obvious asset for certain applications. Low thermal conductivity is useful where handling is necessary, although it retards dissipation of heat. Good surface finish is obtained from the polished die, and apart from trimming, the moulding needs no other finishing, except sometimes light buffing.

The resistance of plastics materials to corrosive media is generally good. Deterioration in damp conditions is prob-

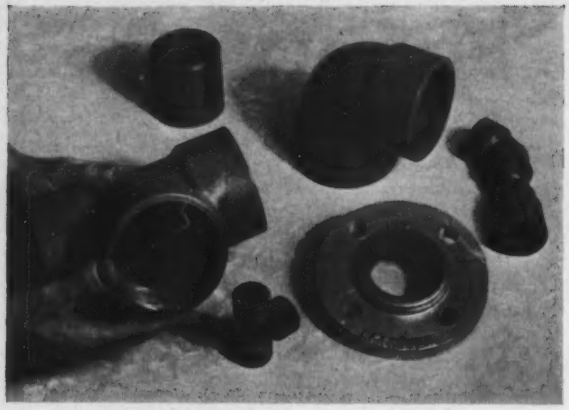
Floating suction strainer with plastic body (photo by Megator Pumps & Compressors Ltd.).



Plastics moulded Free-end coupling which eliminates the need for special fitting procedure, by Airtech Ltd.



Zinc alloy carburetter parts (photo by Z.A.D.A.).



Moulded fittings in Geon p.v.c., by Extrudex Ltd.

ably associated with water absorption, which may occur with the more commonly moulded plastics (other than polystyrene) and which is sufficient to cause the swelling of urea formaldehyde and cellulose acetate mouldings. Changes in humidity lead to dimensional instability in such cases.

Plastics mouldings will not withstand high temperatures; thermoplastics soften at about 100 deg. C., and thermosetting plastics tend to blister if heat is suddenly applied. The maximum temperature for continuous exposure is 180 deg. C. for a heat-resisting thermosetting plastics moulding. In connection with heat resistance, poor thermal conductivity becomes a disadvantage.

Zinc alloys have good castability, and for this reason complex shapes present no difficulty. Components may be produced within very close dimensional limits, which are maintained throughout their life. These alloys possess good resistance to normal corrosion; on outdoor exposure they slowly tarnish, but in doing so form a protective coating.

Some years ago zinc base die castings earned a bad reputation for intercrystalline corrosion, which caused them to break in service even when lightly stressed. In many cases castings cracked and literally fell apart. The cause of this trouble was lack of control in manufacture, which permitted certain impurities such as lead to contaminate the metal. Castings from reputable manufacturers no longer fail in this way under normal service conditions, and a simple test is given in BS 1004 for checking susceptibility to intercrystalline corrosion.

Zinc alloys can be given both protective and decorative finishes by most metal finishing processes. It is common practice to finish castings by plating (with nickel, chromium or some other metal), by painting, lacquering or enamelling, or by some chemical treatment. Castings so finished have a considerably enhanced resistance to corrosion.

Zinc alloy die castings can withstand temperatures up to 150 deg. C., and none of their properties (except impact strength) is affected by exposure to temperatures as low as −40 deg. C. They are often used as conductors in various electrical components where it is possible to provide a sufficient cross-sectional area of metal. The electrical conductivity of zinc alloys is equal to that of brass, and 26 per cent of that of copper.

From Table 1 it will be seen that, in mechanical properties, plastics mouldings are not comparable with zinc alloy die castings. Fuller details of the properties of zinc alloy die castings are given in Table 2. The tensile strengths of moulded plastics, ranging from 1 to 6 t.s.i., are low, the maximum value being only 30 per cent of that of zinc alloy. The thermoplastics show good elongation, but that of the thermosetting materials is negligible.

IMPACT STRENGTH—The impact strength of die cast zinc alloy is normally determined on unnotched bars of ¼ × ¼ in. cross section, using the Charpy testing machine. Plastics are commonly tested by the Izod method, using notched bars of ¼ × ¼ in. cross section, according to BS 771. The figures quoted in Table 1 for moulded plastics represent ft. lb. per in. length of notch, that is, twice the test value, while those for zinc alloy—from room temperature to −40 deg. C.—have been calculated from values obtained from Izod tests on unnotched die-cast bars of 10 × 10 mm. cross section,

Table 2. Mechanical properties of zinc alloy die castings

Alloy	Impact Strength* (ft.lb.)	Tensile strength (p.s.i.)	Elongation (% on 2 in.)	Dim. Ch.† (in. per in.)
A (1)	41·8	42,000	11·4	—
(2)	41·6	35,600	8·5	+ 0·0006
(3)	35·0	35,400	25·0	+ 0·0003
(4)	41·0	33,600	16·0	+ 0·0001
A Stabilised (1)	41·8	42,000	11·4	—
(2)	41·8	35,200	8·1	+ 0·0006
(3)	40·2	34,000	26·4	+ 0·0001
(4)	—	—	—	+ 0·00002 (3 yrs indoor ageing)
B (1)	44·7	48,800	8·3	—
(2)	32·3	40,500	5·1	+ 0·0004
(3)	10·3	37,900	22·7	+ 0·0008
(4)	42·0	41,200	15·0	+ 0·00007

* Charpy ¼ × ¼ in. unnotched.
† Dimensional change (inches per inch) measured 5 weeks after casting, when the initial shrinkage which occurs with these alloys is nearly complete.
(1) As cast.
(2) 10 days steam at 95°C.
(3) 6 months dry at 95°C.
(4) 7 years indoor ageing, except where stated.

Property	*Alloy A*	*Alloy A stabilised*	*Alloy B*
Brinell Hardness	82	82	91
Compressive strength (p.s.i.)	60,000	60,000	87,000
Shearing strength (p.s.i.)	31,000	31,000	33,000
Electrical conductivity (mhos./cu.cm. at 20°C.)	157,000	157,000	153,000
Specific gravity	6·6	6·6	6·7
Weight (lb./per cu. in.)	0·24	0·24	0·24
Thermal expansion per °C.	0·0000274	0·0000274	0·0000274
Melting point (°C.)	380·9	380·9	380·6

Table 3. Comparison of the impact strengths of plastics mouldings and zinc alloy A

Material	Izod Impact Strength—unnotched (10 × 10 mm.) (Ft.lb.)
Methyl Methacrylate	0·7–1·4
Cellulose Acetate	0·5–3·4
Phenol Formaldehyde	
wood filled	0·3–0·5
mineral filled	0·2–0·7
macerated fabric filled	0·7–4·3
Polystyrene	0·6–1·1
Urea Formaldehyde	0·3–0·4
Zinc Alloy A	63·0–9·0

the nearest available size to the ½ × ½ in. plastics test-bar.

A direct comparison between these values is not possible. However, published work includes Izod impact strengths of some moulded plastics obtained on both notched and unnotched bars. This enables the conversion factor

$$\frac{\text{Izod value unnotched}}{\text{Izod value notched}}$$

to be determined, and hence the probable values for unnotched bars equivalent to those quoted in Table 2 for notched bars. Thus a direct comparison between the figures for moulded plastics and zinc alloy is made possible. The Izod impact strengths in ft. lb. for unnotched bars of ½ × ½ in. cross section, estimated in this way, are shown in Table 3. According to these figures, the highest values for moulded plastics occur with fabric reinforced phenol formaldehyde and cellulose acetate. Even so, these values are very considerably below the impact strength of zinc alloy at room temperature and only become comparable with the reduced value for zinc alloy at −40 deg. C. It should be pointed out, however, that except perhaps for polystyrene, thermoplastics become more brittle at lower temperatures. Cellulose acetate exhibits a particularly sharp fall in impact strength with fall in temperature.

The Composite Product

Zinc alloy die castings are used in conjunction with moulded plastics, both as relatively small inserts and as castings representing a large proportion of the composite product. As metal inserts they are used to provide additional strength, to facilitate assembly or to serve as electrical conductors. There are many factors in favour of die cast zinc alloy inserts. Die casting is the most rapid, and in many cases the most economical, form of production of metal components; the more complicated the component the greater is the economy in production compared with other methods.

Zinc alloy die castings, which may include accurately cored holes and screw threads, require little or no subsequent machining. They range in weight from as little as a small fraction of an ounce up to 20 lb., and provide a good bearing surface where necessary. Their coefficient of expansion is greater than that of steel or brass, and thus they are more suitable for use with moulded plastics. They may be cast with knurled or milled surfaces, or with flanges to secure adhesion to the moulding, and it is sometimes feasible when several inserts are required to die cast these on a skeleton framework. This facilitates speedy location of the inserts in the mould, and has the added advantage of stiffening the plastics moulding.

When a plastics coating is moulded over a die casting, the combination is one of adequate rigidity and strength coupled with the decorative value of the plastics. At present this development appears to be confined mainly to more solid articles, such as door furniture, but there would seem to be wider fields of application on account of the thin wall section possible with zinc alloy die castings.

General Conclusions

Although sometimes it is possible to use either plastics mouldings or zinc alloy die castings for a particular component, and thus opinion may be divided, it would appear that the known facts justify the following general conclusions on the applications of the two materials.

Plastics mouldings are likely to have little effect on engineering applications of die castings where high mechanical properties and dimensional stability are required. In such cases zinc alloy die castings will hold their own. For ornamental uses, however, they are likely to meet with serious and increasing competition from plastics mouldings. As regards the use of the two materials in combination, the future appears to hold out many new and interesting possibilities, in which full advantage will be taken of particular merits such as the strength of the metal and the decorative appearance of the plastics.

The author is indebted to the Zinc Alloy Diecasters Association for information on which this article is based.

SINTERED METAL FIBRES

IMPROVED materials for engineering applications, ranging from filters and battery plates to fragmentation armour and rocket nozzles, may result from a new technology called fibre metallurgy, which is under development at the Illinois Institute of Technology. This new technology is centred around a basic process in which metal fibres are felted as in paper making, and the felted fibres then sintered as in powder metallurgy. That is, randomly interlocked, felted fibres are heated to form a metallic weld bond at each point of contact between them. The fibres, which may be either all of similar length or of random lengths, are crimped so that they have random three-dimensional kinks.

The felted fibres are sintered in a reducing atmosphere at temperatures sufficiently high to obtain metal diffusion and substantial metallic bonding where fibres contact one another. This critical step transforms the loose felt into a comparatively rigid three-dimensional fibre network. Depending upon the length : diameter ratio of the fibres and the density of the porous network, each fibre may be bonded at as many as 100 points to neighbouring fibres. Therefore, even though the bonds are not individually as strong as the fibres, the network is strong because of this multiplicity of bonds. The sintered metal fibre bodies may be further compacted, rolled, machined, welded, brazed or treated in a variety of ways to fabricate finished, useful components having porosities of 5-97 per cent. Among the materials which have been treated in this way are lead, copper, iron, nickel, cobalt-base alloys, titanium and molybdenum.

It appears that no metal or alloy is impossible to treat by fibre metallurgy, although those which form stable surface oxide films, e.g., aluminium, are difficult to sinter. The finished basic fibre metal products are materials of unusual properties. They may look and feel like a metal sheet, but have less than 10 per cent of the density of the metal. They may also have a comparatively high density, but also a high permeability, so that gases or fluids readily flow through.

The labyrinth-like structure of the metal fibre materials suggests that acoustical vibrations may be very effectively dissipated, particularly by the low-density compacts. A good sound absorber which is in addition a good high-temperature, corrosion-resistant structural material would be of considerable value. Fibre metal materials also absorb mechanical vibrations; that is, they have a high internal damping capacity. This property is of considerable value for a structural material, for example in the anti-vibration mounting of machinery or electronic components.

Since the pores of fibre metal materials are continuous and the surface-to-volume ratio of fibres is high, a porous metal fibre material has a very large surface area. For catalysts, separators, battery plates and many other applications, such high surface areas are desirable. Fibre metal materials can provide this attribute in conjunction with good structural characteristics.

SELF-LUBRICATING BEARINGS

Major pioneering work carried out during the 1930s has inaugurated the modern era of "lighter and tougher", in which synthetic materials are well on the way to replacing metal parts in specific applications

by **PAULINE LONG**

AFTER it was found that the basic chemistry and technique in production of synthetic rubbers was closely akin to the manufacture of plastics, research teams discovered these synthetic materials, far from being inferior to the conventional products which they were to replace, made possible new standards of design and engineering.

Plastics for precision engineering have been later in developing than those involved in material replacement, but for many years a number of firms have been working in this field, and have already made progress that is having a recognisable effect on mechanical engineering. From the basic work being performed, and the scale of the progress made, there appears to be little doubt that within the next decade the same sort of changes will be seen here as in other sections of industry. Plastics are being developed to offer the engineer answers to age-old problems associated with bearing design—on the one hand to provide bearings that can run with either little or no lubrication, and on the other to enable him to design machinery that is lighter than previously supposed possible, with higher efficiency throughout. Plastics bearings which are able to withstand arduous conditions of corrosion and dirt without the need for maintenance are already available and in use, performing tasks which were impossible with conventional materials, in the realms of supersonic aircraft, rockets, atomic energy, polar exploration, etc. These plastics are becoming available for everyday use, examples being seen in the heavy and light automotive industries, industrial plant and marine engineering.

The purpose of this article is to indicate the various plastics which are becoming available for use as bearing surfaces, with particular emphasis on those which have either made normal lubrication maintenance unnecessary, or reduced it significantly. In considering the replacement of a conventional metal bearing by one made of plastics it is advisable to consider carefully whether the full advantages of the plastics may be realised if it is used as a direct replacement. In many instances direct replacement of materials without reconsidering the design can often lead to loss of efficiency rather than improvement. Design and material selection must not be considered separately; they must present an integral problem.

Fluoro-carbons

The use of the fluoro-carbon polymers for bearing surfaces is becoming increasingly well known, the most interesting

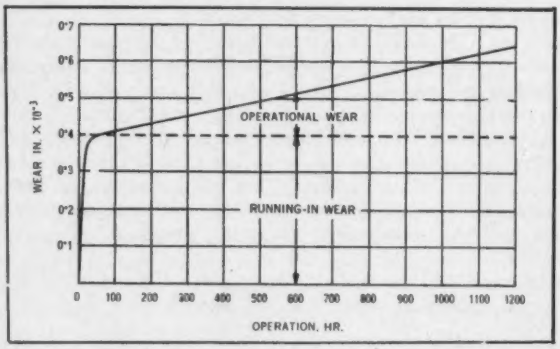


Fig. 1. Typical wear/time relationship for reinforced p.t.f.e. materials (Glacier Metal Co. Ltd.).

Table 1. Comparison of the most important properties of p.t.f.e. compared with those of nylon, polythene and polystyrene (these materials are competitive in some fields). The figures given are typical for moulded pieces, but should only be taken as a general guide.

	Fluon (I.C.I.)	*Polythene*	*Polystyrene*	*Nylon*
Tensile strength (p.s.i.)	2,000	1,850	7,000	> 10,000
Elongation at break (%)	50–400	550	3	80–100
Young's modulus (p.s.i. × 10^5)	0·58	0·25	5·2	> 3·0
Impact strength (Izod)	4·0	> 3·0	0·3	2·5
Density (gm./cm.^{3})	2·2	0·92	1·05	1·14
Heat resistance (°C.)	250–300	100	95	150
Volume resistivity (ohm-cm.)	> 10^{19}	ca. 10^{19}	ca. 10^{19}	10^{13}
Dielectric strength (volts per mil., $\frac{1}{8}$ in. sheet)	500	1,000	1,000	400
Dielectric constant	2·0	2·3	2·5	4·0
Power factor	0·0001	0·0002	0·0002	0·02
Surface arc resistance	> 100 Does not track	> 100	> 100	> 100
Resistance to acids	Complete	Very good	Some attack	Attacked
Resistance to alkalis	Complete	Very good	Very good	Very good
Resistance to solvents	Complete	Resistant to most solvents	Attacked	Resistant to some solvents

(I.C.I. Ltd.)

characteristic being the extremely low coefficient of friction. In its best known form, p.t.f.e. (polytetrafluorethylene), the coefficient for static friction against polished steel is as low as 0·04, while dynamic friction values of 0·07 to 0·14 have been obtained. These fluoro-carbon polymers make true "dry" bearings, for which no lubrication is necessary. They are significant for their high temperature and flame resistance, good electrical properties and chemical stability. Their working range is generally within −100 deg. C. to 250 deg. C.; they are non-wettable with zero moisture absorption, have low gas permeability, and in certain forms remain stable during temperature changes (see Tables 1 and 4).

In its massive state p.t.f.e. shows poor mechanical strength, and in order to use its excellent non-stick properties for bearings it has been necessary to add reinforcement. The Glacier Metal Co. Ltd., which has pioneered the development of p.t.f.e. bearing surfaces, is manufacturing DU bearings, which are made up of three layers: (a) a backing strip of steel, tin-plated to protect it from atmospheric corrosion; (b) a middle layer of porous tin-bronze (made by sintering a layer of spherical bronze powder on to the steel backing) filled solidly with a mixture of p.t.f.e. and fine lead powder; and (c) an overlay about 0·001 in. thick of the same p.t.f.e. lead mixture (see Figs. 1 and 2).

Another approach has been made by Polypenco Ltd., who make a p.t.f.e. reinforced resin called Fluorosint. The actual methods of reinforcement are not at present disclosed, but it appears that the mechanical and thermal properties of the p.t.f.e. have been improved without materially affecting its electrical and chemical properties. Bearings can operate at high loads and speeds, and a p.v. factor of over 15,000 is claimed (see Fig. 3). This is comparable with the performance of the DU materials.

Mintex* fluoro-carbon surfaced bearings for high load and low speed applications are based on Teflon† p.t.f.e. fibres, the thermal stability of which is exceptional, and may be considered for use in the temperature range of −195 deg. C. to 200 deg. C. Owing to the outstandingly high load-carrying capacity of the fibre (60,000 p.s.i. without cold flow), it is advantageous to back it up with a material of comparable compressive strength and suitable elastic modulus, so as to provide a composite material capable of adapting itself to surface irregularities and misalignment, and able to withstand and cushion high shock loads. As a consequence of this, manufacturing tolerances wider than normal are possible. When considering the design of bearings incorporating fluoro-carbon material it should be remembered that these have low heat-transfer rates, and allowances should be made in design when fitting these materials. P.t.f.e. surfaces are compatible with materials such as mild steel, stainless steel and phosphor bronze, all of which give satisfactory results, and probably slightly lower average friction values than hard chromium plate. Owing to the high cost of p.t.f.e., however, it should be used only where required, i.e. at the working surface. With reference to Fig. 5, it is important to recognise that while the values for μ are the results of actual tests, they will not necessarily be exactly reproducible in different tests or different applications.

As it becomes possible to use these plastics by appropriate methods of reinforcement, the demand for bearings made of these materials will increase from many industries. Due to its low temperature stability it can be used in pumping plants with liquid oxygen (at −192 deg. C.) and nitrogen; at the other end of the temperature scale a demand will come from designers of furnaces and aero engines. An interesting application, in Canada, is where the brake mechanisms of Toronto buses have been converted to DU bearings because the grease used on conventionally lubri-

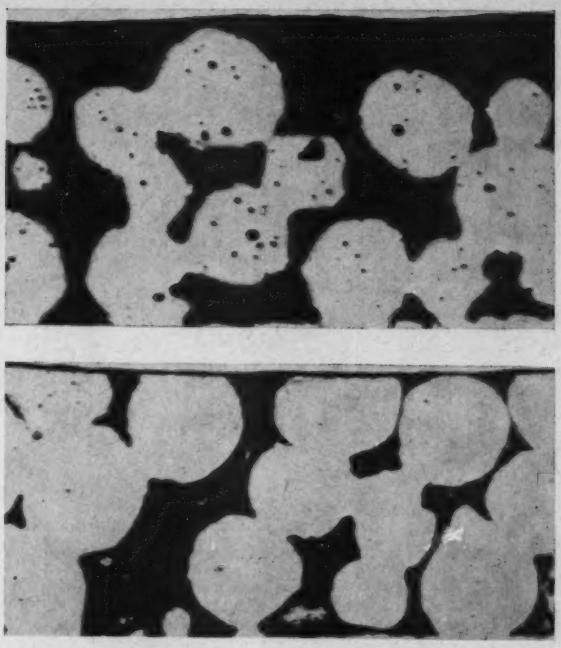


Fig. 2. (*top*) Section through Glacier DU bearings before running-in, showing p.t.f.e./lead, porous bronze matrix and steel backing; (*bottom*) bearing after running-in, showing worn bronze spheres covered by a very thin layer of p.t.f.e./lead. Wear after running-in is approximately 0·001 in.

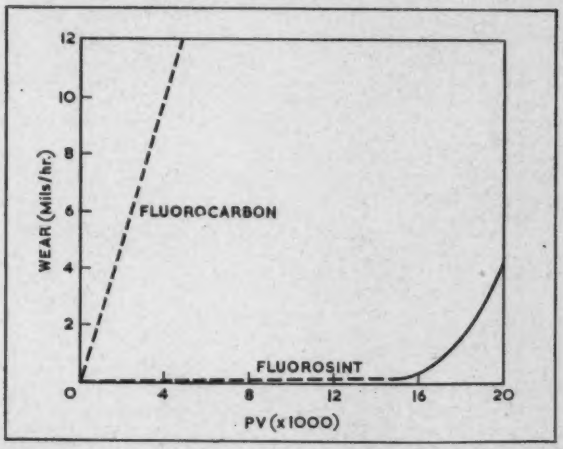


Fig. 3. Wear characteristics of Fluorosint (Polypenco Ltd.).

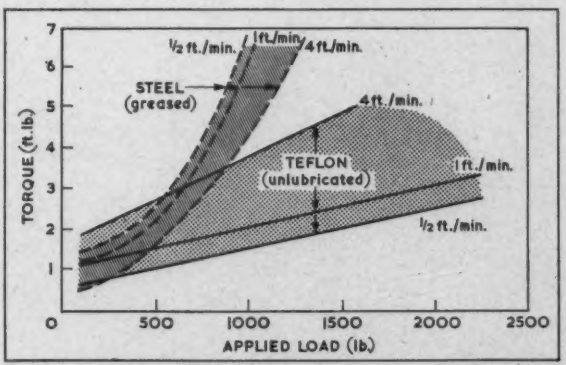


Fig. 4. Relationship between torque and applied load of an unlubricated p.t.f.e. socket, compared with a lubricated steel socket (automobile suspension) (E. I. Du Pont de Nemours & Co., U.S.A.).

* *British Belting & Asbestos Ltd.*

† *E. I. Du Pont de Nemours & Co., U.S.A.*

Table 2. Properties of Fluorosint (Polypenco Ltd.)

Property		Fluorosint	Fluoro-carbon	Filled Fluoro-carbon		Nylon	
				35% Glass	35% Graphite	Dry	2·5% Moisture
Flexural modulus (p.s.i.) at:	23°C.	464,000	80,700	208,000	162,000	420,000	205,000
	100°C.	442,000	28,700	113,000	76,000	93,000	70,000
	260°C.	144,000	6,500	25,900	27,200		
Compressive modulus (p.s.i.) at:	23°C.	253,000	84,300				
	100°C.	145,000	—				
	260°C.	52,600	—				
Tensile modulus at:	23°C.	190,000	90,000				
Specific gravity		2·3–2·4	2·15–2·2				
Hardness-D scale		70–75	50–55				
Tensile strength (p.s.i.)		2,000–2,500	1,500–3,000				
Elongation (%)		10–200	75–350				
Deformation under load (%)							
(1,200 p.s.i.: 24 hr.;	150°C.)	1·3	14–18				
(1,200 p.s.i.: 24 hr.;	200°C.)	1·6	22–30				
Coefficient of thermal expansion/°F.:							
70–140°F.		$1·1 \times 10^{-5}$	$6·9 \times 10^{-5}$				
70–500°F.		$1·7 \times 10^{-5}$	$9·7 \times 10^{-5}$				
Dynamic coefficient of friction		0·16	0·24				
Flammability (in./min.)		does not burn	does not burn				

Table 3. A comparison of some properties of various I.C.I. Maranyl nylon compounds

Property	(A100) Type 66 Polymer (Un-plasticised)	(B100) Type 610 Polymer (Un-plasticised)	(LA38) 66/610 Copolymer (Plasticised)	(LA48) Type 66 Polymer (Plasticised)	(DA) 66/610/6 Copolymer (Un-plasticised)	(B101) Stabilised Type 610 Polymer	(LA29) 66/610 Copolymer (Un-plasticised)
Tensile strength							
At yield (p.s.i.)	11,500	8,500	—	—	—	8,500	5,500
At break (p.s.i.)	—	—	5,000	7,000	7,500	—	—
Elongation at break (%)	80–100	100–150	200–250	100–120	300	100–150	>200
Young's modulus (p.s.i.)	$4·3 \times 10^5$	$3·0 \times 10^5$	$0·5 \times 10^5$	$1·8 \times 10^5$	$2·2 \times 10^5$	$3·0 \times 10^5$	$2·2 \times 10^5$
Impact strength (ft.lb./½ in.)	1–1·5	1·6–2·0	>10	2·0	—	1·6–2·0	2·0
Hardness (Vickers Diamond)	12	11	3	7	—	11	—
Melting point (°C.)	264	220	184	255	160	220	—
Heat distortion temperature (°C.) (264 p.s.i.)	75	55	40	55	35	55	—
Volume resistivity ohm-cm. (20°C. and 70% R.H.)	10^{13}	10^{14}	10^{10}	10^{10}	10^{13}	10^{14}	10^{13}
Water absorption (%)	1·50	0·33	0·70	0·80	1·99	0·33	0·90
Low-temperature flexibility (°C.)	−70	−70	−70	−60	−60 to −70	−70	—
Specific gravity	1·14	1·09	1·12	1·16	1·09	1·09	1·08

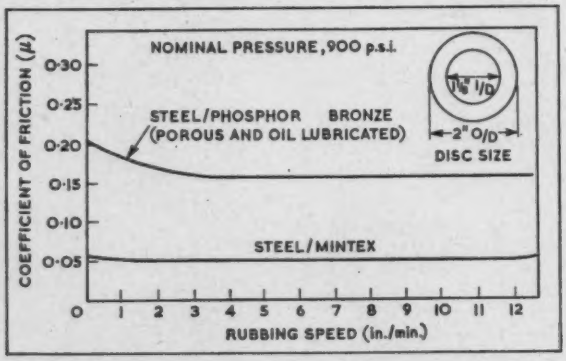


Fig. 5. Relationship obtained between μ and mean rubbing speed in a thrust washer application used in the king-pin assemblies of automobiles. (British Belting & Asbestos Ltd.).

Table 4. Some wear performance comparisons

Bearing material tested against mild steel with ground surface finish of 16CLA (BS 1134:1950)	Testing time (hr.)	Wear at end of test (ins.)
Reinforced p.f.t.e. (Glacier DU) ...	1,000	Less than 0·001
Graphite and lead bronze ...	158	0·010
Oil-impregnated porous bronze	105	0·010
Phenolic resin with molybdenum disulphide...	73	0·005
Graphite: bearing grade	24	0·005
Woven asbestos impregnated with resin and molybdenum disulphide	0·8	0·005
Nylon	0·3	0·010

Comparison tests carried out at PV = 16,000 p.s.i. × ft./min. are given in the above table. Thrust washers were used in these tests rather than journal bearings to avoid such difficult variables as uniformity of loading, initial clearance and increasing clearance with wear, which latter was in some instances substantial.

(Glacier Metal Co. Ltd.)

cated bearings froze during winter. In Sweden one of the leading firms of heavy commercial vehicle makers has used this material for bearings throughout the automotive chassis. There appears to be an almost unlimited field for such materials in the automotive industries, as it is acknowledged that many of these bearings need no lubrication or maintenance.

The necessity of using oil as a cooling medium is likely to preclude the use of dry bearings within an engine, thus the practical realisation of a non-lubricated engine is still some way off. The textile industry is adopting the fluorocarbon bearing on account of its cleanliness and the absence of the necessity for oiling, which is likely to contaminate the processed products. Other comparable outlets are in the food and drink industries. These plastics are rather intolerant of dirty conditions and should not be selected where these may cause abrasion. There is also the necessity for cleanliness during the handling and manufacture of p.t.f.e. bearings, as the material may easily develop a static charge and attract dust.

Attempts have been made to deposit thin adherent films of p.t.f.e. on metal substrates to prepare low-friction bearing surfaces. A successful method reported by D.S.I.R. uses a dilute aqueous suspensoid which on drying leaves a layer of p.t.f.e., which is consolidated by heating to 350 deg. C.; several methods of avoiding excessive oxidation of the metal have been investigated. The thin films of p.t.f.e. deposited on copper showed remarkably low frictional properties, which were maintained to temperatures above 300 deg. C. with excellent durability and wear resistance. A disadvantage, however, is the extreme accuracy required in manufacture and fitting to avoid high local loading and consequent breakdown.

Nylon

As far as vehicle chassis are concerned, designers can make substantial savings in finished weight by using non-lubricating bearings, which also reduce operating and maintenance costs. A typical example is in the Triumph Herald motor car, which uses a nylon material less expensive than the fluoro-polymers but with a far more limited temperature range and loading. The nylon polymers are finding increasing acceptance in light engineering, where bearings are designed for everyday use in a whole range of consumer industries. Nylons in their various grades are tough, resistant to abrasion, and possess high tensile strength* with a good resistance to organic solvents, maintaining a high impact strength down to sub-zero temperatures with excellent flexibility. Whether in massive form or as a reinforced material they are easy to fabricate, cut and machine to any shape. They have a low coefficient of friction and in some applications can be used dry; in other applications lubrication will increase their efficiency. Figures given for Polypenco nylon bearings used with a steel shaft show a maximum practical p.v. of 7,000 for non-lubricated nylon, but 40,000 for lubricated nylon. Shafts made from a more ductile material such as brass or aluminium will require lower p.v. values. In most grades of nylon there is some moisture pick-up, although current research and development is directed to obviate this entirely.

The coefficient of friction of nylon, sliding either on itself or on steel, varies from 0·15 to 0·30; with grease or oil lubrication values down to 0·05 are possible (this figure applying to the lubricating film and not the material). Good hydrodynamic lubrication (that is, lubrication with a complete film of fluid between journal and bearing) is difficult to obtain because of the large clearances required with this type of material, but nylon offers the advantages of good resistance against wear and abrasion, and low coefficient of

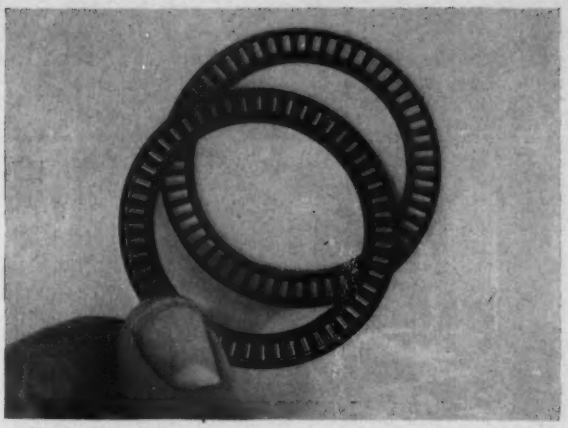


Fig. 6. Glass filled nylon cages for thrust bearings (Garlock Packing Co.).

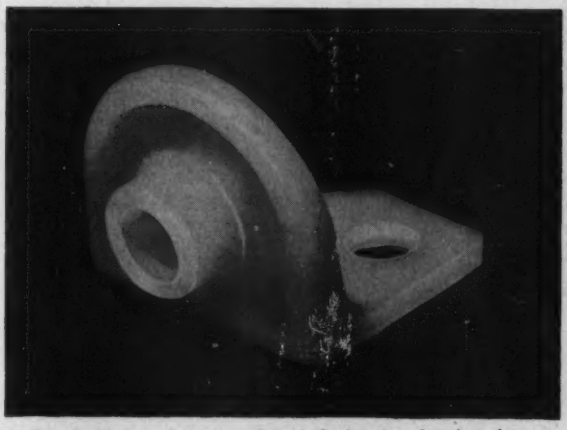


Fig. 7. Nylon throttle relay shaft bearing bracket for a sports car (Spa Plastics).

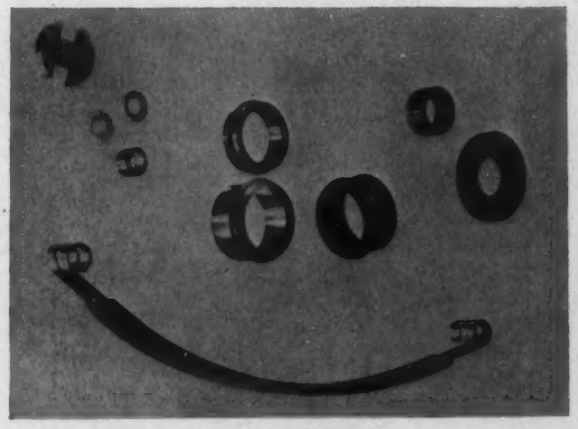


Fig. 8. Small and medium-size car components incorporating Vulkollan.

Table 5. Strength of Bakelite (Bakelite Ltd.) laminations

Type	U.t.s. (p.s.i.)
Paper base sheet	8,000–14,000
Fabric base sheet	5,000–19,000
Compregnated wood	14,000–27,000
Densified wood	20,000
Glass fabric sheet	22,000–28,000
Asbestos based sheet	6,000– 9,500

* *See* Engineering Materials and Design, *December* 1958.

friction, for low speeds and rough service conditions. The large clearances necessary with nylon bearings are due to the dimensional changes caused by moisture absorption and temperature variations.

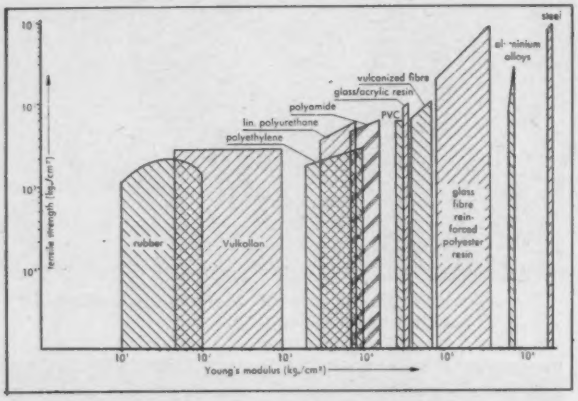


Fig. 9. Tensile strength and Young's modulus for various materials (Rubber Plastics Ltd.).

Fig. 10. Bearing machined from Bakelite laminated materials.

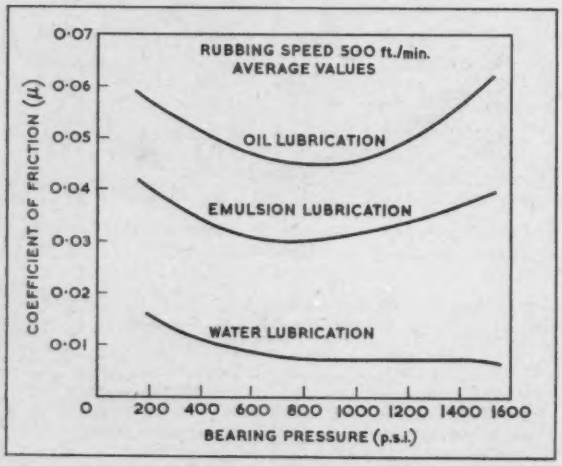


Fig. 11. Friction characteristics of Texolex lubricated with oil, emulsion or water.

Generally, a bearing wall-thickness of 10 per cent of the bore is recommended, and a heavy press fit must not be used since it may cause distortion. On the other hand a normal tight fit, as used for metal bearings, may give insufficient fastening due to the stress-relaxation properties; this will be the case especially where there are large changes in environmental temperature and relative humidity. For these reasons the bearing or bush should be fixed by means of bolts, pins, spring collars and so forth. Alternatively, cementing the bearing into its housing is recommended in cases of low loads and constant environmental conditions. Axial fastening can be obtained with an exterior circumferential rib that fits into a groove in the mounting. This fastening method is made possible by the flexibility of nylon.

Among the many new developments in the manufacture of nylon materials for bearings is the production of Polypenco Nylatron G.S. (a molybdenum di-sulphide filled nylon) and Nylasint (which involves the sintering of finely divided nylon powder alloyed with inorganic additives to produce a material of superior mechanical and thermal properties). In this way nylon can also become microporous, and absorb and maintain up to 25 per cent of fluids by weight.

Nylastic* bearings are suitable for slow-moving, sliding or reciprocating applications, where they may be operated without the need for lubrication, examples being suspension pivot points, and brake rod and gear change applications in private cars and commercial vehicles. Nylastic may be operated within a p.v. factor of 5,000, or where the maximum static loading does not exceed 2,000 p.s.i. It will operate fully immersed in water and in temperatures up to 135 deg. C. Composite bearings are also available in which rubber is used with nylon for both light and heavy duties. It is claimed that these composite units have the advantage that rotation of the shaft can take place without torsional resistance from the rubber, the rubber alignment giving a high degree of isolation from vibration.

Nylon may be used to coat metal parts to provide low friction surfaces, and it can also be filled with glass fibre or other similar fillers. In this direction much research and development is taking place.

Polyurethane Elastomers

These are relatively new, and are best known in the foamed form used in building, furniture and allied constructions. It is, however, as a hard synthetic rubber that polyurethane may be used for bearings. Such rubbers are based upon the pre-war German work of Dr. Bayer and his team, who produced Vulkollan. Recently, these synthetic polyurethane rubbers have been produced in the U.K. by Rubber Plastics Ltd., who offer Vulkollan in various grades and their own Rublastic, which is a material based on further development of the polyurethanes. Precision Rubbers Ltd. are also working on these materials, as are I.C.I Ltd.

The raw materials of these elastomers are aromatic diisocyanates and polyisocyanates cross linked with water and polyhydric alcohols. In varying combinations these ingredients produce foams, adhesives, lacquers, coatings and finally rubbers in varying grades of hardness. These are characterised particularly by a high tensile strength, a high resistance to abrasion and tear, and resistance to the effects of oxygen, ozone, petrol and oil. They have a fair temperature range, are hygroscopically stable, and may be bonded to metals and fabrics. Operations such as grinding, turning, drilling or milling may be carried out on the harder grades.

One of the properties of the material is an unusual degree of resilience associated with high Shore Hardness (95-100),

* *Howard Clayton-Wright Ltd.*

Table 6. Mechanical and thermal properties of Vulkollan. The values quoted are for guidance only, and were taken at room temperature and normal relative humidities*

Type of test	Units	Quality						
		18W	18/40	18	25	30	40	50
Density	gm./cm.³	1·26	1·26	1·26	1·26	1·26	1·26	1·26
Tensile strength	kg./cm.²	300	300	300	300	300	300	300
Elongation at break	%	650	600	650	600	450	400	400
Modulus at:								
20% elongation	kg./cm.²	10	7	15	50	70	100	140
300% elongation	kg./cm.²	100	50	70	150	175	210	250
Permanent set	%	20	5	15	30	35	40	40
Rebound elasticity	%	60	47	50	50	45	44	42
Shore-hardness A	hardness units	70	65	80	90	93	95	96
Tear resistance (Graves)	kg./cm.	75	25	55	70	70	90	90
Switch tear resistance	kg./cm.	110	60	90	105	110	120	130
Abrasion resistance†		35	50	40	60	60	60	60
Heat conductivity	kcal./m. h. °C.	0·25	0·25	0·25	0·25	0·25	0·25	0·25
Coefficient of linear thermal expansion 20–50° C.	10⁻⁶/°C.	210	200	180	210	220	180	190
20–100° C.		190	190	180	200	190	160	190
Specific heat	cal./°C./gm.	0·45	0·45	0·45	0·45	0·45	0·45	0·45

* Manufactured in the U.K. by Rubber Plastics Ltd. † Calculated on abrasion resistant natural rubber = 100.

creases with an increase in hardness. Also, while they provide sealing properties and vibration insulation, Vulkollan and similar materials do not withstand very high temperatures.

Normally, bearings of this material are oil or grease lubricated, but grades are available with a lubricant such as MoS_2, which has a low coefficient of friction; water lubrication is also adequate for any grade. Because of their resistance to petrol and oil, bearings of Vulkollan are particularly useful in the automotive industry for use with shafts in the steering mechanism, engine bearers and bushes, shackle pin bushes on leaf-type springs, anti-rattle handbrake lever bearings, trunnion bushes for front ends of tractors and so forth.

Their combination of high abrasion resistance with a medium temperature range means that they can be considered for use as bearings where speed is unimportant compared with high loadings, and where conditions of dirt, abrasive matter and contaminated liquids exist. Examples may be found in heavy earth-moving equipment, track-laying bulldozers, heavy industrial engines in dirty conditions and snow ploughs. Other applications are in pumps dealing with chemicals and abrasive and corrosive liquids. Polyurethanes are found to be satisfactory for marine uses, where the heat produced by high speeds is no problem if the bearing is totally submerged. Such a use is a propeller shaft bearing.

Table 7. Properties of MoS_2 filled nylon (Nylatron GS, made by Polypenco Ltd.)

Specific gravity		1·14
Tensile strength (p.s.i.)	22·8°C.	12,300
Elongation (%) at:	−57°C.	8–18
	22·8°C.	30–60
	76·7°C.	160–320
Flexural strength (p.s.i.)	22·8°C.	18,000
Impact strength, (Izod, ft.lb.)	22·8°C.	0·62
Shear strength (p.s.i.)	22·8°C.	10,000
Modulus of elasticity (p.s.i.)	22·8°C.	575,000
Compressive yield stress (p.s.i.)	22·8°C.	15,050
Stiffness (p.s.i.)	22·8°C.	280,000
Hardness, Rockwell	22·8°C.	M89
Heat distortion temperature (°C.)	264 p.s.i.	163
Heat distortion temperature (°C.)	66 p.s.i.	232
Flow temperature (°C.)		>250
Coefficient of linear thermal expansion		$3·5 \times 10^{-5}$
Thermal conductivity (B.t.u./ft. hr.°F.)		2·0
Flammability		self-extinguishing
Melting point (°C.)		264

Phenolic Laminates

In contrast with the above group, the phenolic laminated plastics are among the oldest known, and progress has been such that the original Bakelite materials now include hard laminates suitable for gears, bearings and bearing cases. Laminates are manufactured by the impregnation of fabric or similar material by phenol-formaldehyde resin varnishes, the impregnated sheets being stacked into presses and subjected to pressure and heat, which causes chemical changes in the resin structure so that it is no longer affected by subsequent heat or attacked by solvents (see Fig. 10).

These bonded and moulded materials not only possess high strength and impact resistance but have high wear resistance under certain circumstances. A major outlet for these materials has been rolling mills for both ferrous and non-ferrous metals. The major factor influencing the use of these materials in rolling mills is the fact that practically all mills use water for cooling purposes. When water saturated, cotton fabric laminates increase in strength, and in addition the water provides boundary lubrication. The major disadvantage with the material is its low thermal conductivity, friction generated heat being unable to dissipate through the mill housings. The cooling water normally applied to the mill thus becomes essential in order to minimise the skin temperature of the roll necks. Rolling mills are, therefore, a natural application where cooling water or emulsions are already in use. Asbestos reinforced phenolic laminates are also available, and may be impregnated with oil or colloidal graphite. These are less susceptible than cotton to dimension changes due to the absorption of fluids, and are not liable to rot. In service, laminated fabrics usually incorporate inert fillers in the resins, which impart a high polish to the roll necks. In addition, scale particles tend to embed in the fabric rather than remain on the surface, thus preventing scoring of the roll.

Apart from their use in rolling mills these materials are now used extensively for a wide variety of mechanical handling equipment, where the loads and speeds are such that grease lubrication only is employed, and in some instances dry running. Various grades are available for specific duties, and technical data relating to the material is available from reputable manufacturers. The characteristics of these

a contrast to the more usual state where the elasticity delaminated materials include a resistance to most chemicals. They also have good electrical properties, and a high compressive strength coupled with a low modulus of elasticity.

Among the best known types are Tufnol,[1] Ferobestos,[2] Texolex,[3] and Mintex,[4] all of which have been successful in marine applications, where it is claimed that considerable reduction of maintenance costs has resulted from the use of these materials for rudder and stern tube bearings. Water is one of the best forms of lubrication, and mildly corrosive fluids and emulsions can also be used. In fact, any fluid that does not attack the mating surfaces or cause breakdown of the material can be used as a lubricant. Where fluid lubrication is not possible, an MoS_2 filled material is available as a self-lubricating type.

Mintex M6H is an example of a water-lubricated bearing material of felted asbestos reinforced cresylic resin which is easily machined, readily wetted, capable of accommodating high local loading, and which may be used as a direct replacement for lignum vitae. Other forms of Mintex are impregnated with oil or graphite either singly or in combination, and are self-lubricating, but they may have a supplementary water and/or oil lubrication. Many of these materials do not resist a high temperature, and it is advisable to keep them to about 85 deg. C., but certain materials, Mintex for example, are capable of sustaining a working temperature of 150 deg. C. with short overload periods up to 250 deg. C. They are available as tubes and rods, or in block form, and can be machined in the normal way.

Another form of impregnated bearing is produced by Stabel Products Ltd., in which the bearing is made from low moisture content timber, either beech or Canadian rock maple, and impregnated with a combination of wax or grease under a vacuum and pressure process. Bearings of this type are particularly useful for farm machinery.

Molybdenum Di-sulphide

Molybdenum di-sulphide has been previously mentioned as a filler for plastics to provide self-lubrication. Used primarily as a solid film lubricant, it has been used in conjunction with metals for some time, and provided many of the first self-lubricated bearings. When added to plastics, usually during the process of their manufacture, it provides a lower surface friction and increases the resistance of the plastics to cold flow, providing better dimensional stability and thermal conductivity.

Among the plastics, nylon appears to benefit most; added in quantities of 5-20 per cent it will produce optimum nylon bearing properties. The addition of MoS_2 to p.t.f.e. to improve its coefficient of friction is unnecessary, but it has been claimed that by impregnating with MoS_2, wear resistance and mechanical properties are improved, and there is a reduction in cold flow. As far as the phenolic laminates are concerned, adding 6-12 per cent MoS_2 to the phenolic laminates before impregnation imparts wear resistance at high temperatures, and provides the self lubrication necessary in certain applications. Work has been proceeding on the filling of epoxide resin laminates with MoS_2, and this may lower their high frictional characteristics sufficiently to allow their use in applications subject to impact and high loading. In general it would seem that the addition of MoS_2 will help with resistance to higher temperatures in a number of plastics, as well as providing self-lubricating characteristics.

The use of dry and self-lubricating plastics for bearing materials is still in its infancy. Developments are continually being made, and new polymers such as Delrin and Viton A (distributed by Du Pont Co. (U.K.) Ltd.), which combine high temperature resistance with hardness and elasticity, are being manufactured. Efforts are also being made to reach higher temperatures with compounds based on the organo-silicates. Problems of self-lubrication are implicit in satellites, rockets and space vehicles, since normal maintenance routines are obviously impossible. As such problems are solved, the basic design experience will become available for commercial exploitation.

Manufacturers and Suppliers

The following table indicates the principal manufacturers and suppliers of plastics and plastics impregnated bearings, and the author wishes to acknowledge their co-operation in the preparation of this article.

	P.t.f.e.	Polyurethane	Nylon	Phenolic impregnated laminates	MoS_2	Silicone
Bakelite Ltd.				o		
Beldam Asbestos Co. Ltd.	o					
Bound Brook Co. Ltd.	o					
British Belting and Asbestos, Ltd. (Mintex)	o			o	o	
The Bushing Co. Ltd. (Texolex)				o		
Burns (Ilford) Ltd.				o		
Howard Clayton-Wright, Ltd.			o			
Climax Molybdenum Co. Ltd.					o	
Coin Insulation Ltd.				o		
R. H. Cole Ltd.		o	o			
Durapipe and Fittings Ltd.			o			
Glacier Metal Co. Ltd.	o					
Germ Lubricants Ltd.					o	
Insulated Components and Materials Ltd.				o		
I.C.I. Ltd.	o					
Ioco Ltd.				o		
Kent Mouldings Ltd.	o					
Lacrinoid Ltd.	o					
Mobil Oil Ltd.						o
Mica and Micanite Supplies Ltd.				o		
Micanite and Insulators Ltd.				o		
M. and B. Plastics Ltd.			o			
Melwood Thermoplastics Ltd.			o			
National Plastics (Sales) Ltd.	o					
Nylonic Ltd.			o			
Punfield and Barstow Ltd.			o			
Polypenco Ltd.	o		o			
Precision Rubbers Ltd.		o				
Powder Metallurgy Ltd.	o					
K. S. Paul (Molybdenum disulphide) Ltd.					o	
Permali Ltd.	o					
Rocol Ltd.					o	
Rubber Plastics Ltd.		o				o
J.W. Roberts Ltd. (Ferobestos)				o		o
Shell Chemicals Ltd.					o	
Simmonds Aerocessories Ltd.		o				
Spa Plastics Ltd.			o			
J. M. Steel and Co. Ltd.		o				
Tufnol Ltd.				o		
United Coke and Chemicals					o	
Vulcascot (Gt. Britain) Ltd.				o		
Edgar Vaughan Co. Ltd.					o	
Whiffen Ltd.			o			
Wemyss Woodhouse Ltd. (Akulon)			o			

REFERENCES

[1] *Tufnol Ltd.*
[2] *J. W. Roberts Ltd.*
[3] *The Bushing Co. Ltd.*
[4] *British Belting & Asbestos Ltd.*

HIGH-TEMPERATURE INSULATION FOR WIRE

THE speeds associated with the present and future developments of missiles, rockets and aircraft have imposed severe high-temperature requirements on many components used in these vehicles. This service environment has created a general need for the development of new materials operative in this high-temperature range.

To keep apace with this general progress, material and processing development programmes for electrical insulation effective beyond the upper temperature limit of organic insulation (about 300 deg. C.) have been undertaken in the U.S., the principal objectives being as follows:

(a) Development of materials for high-temperature electrical insulation on wire.
(b) Development of methods for applying and processing such insulation.
(c) Evaluation of physical, mechanical and electrical properties of the insulating coatings developed through this programme.

The development of electrical insulating coatings was directed towards the following target requirements: electrical insulating over the temperature range −65 to 800 deg. C.; high dielectric strength (400 volts/mil. or higher); low loss tangent (1 per cent and smaller); low dielectric constant (4·5 maximum); flexibility at room temperature, such that a coated wire can be wrapped around a mandrel (the diameter of which is ten times that of the wire) without destroying electrical insulation (the greatest need for flexibility at room temperature is during installation); high impact strength; high abrasion resistance; pressure change resistance; thermal shock resistance; corrosion resistance to oils and salty atmosphere; minimum weight; maximum imperviousness to moisture; maximum reflectivity; concentricity of coating; and life expectancy of at least 10,000 hours. Many ceramic-type insulations were formulated and examined for physical and electrical properties, and single and double coatings were applied to various wires. Preliminary trials with continuous coatings on Inconel and stainless-steel clad copper wire resulted in coatings with relatively poor bond.

Flexibility tests of coated wire indicated that, in order to avoid cracking the coating at a mandrel:wire diameter ratio of 10:1, the coating thickness should be about 0·1 mil. or less. However, electrical breakdown tests of single and double coated wire wound on to a ¼-in. dia. mandrel (which caused numerous tiny cracks on the tension side of the wire) resulted in dielectric strength values in excess of 400 volts per mil., despite these cracks in the coating.

A further approach made was the combination of an organic and inorganic coating in the form of a resin with a powdered glass filler, the resin providing the necessary initial flexibility. Once this insulation system is heated up, the resin should burn out and the powdered glass filler should fuse, forming a continuous coating to 800 deg. C. At this temperature, however, a vitreous enamel coating would have poor electrical properties unless a stand-off insulator were provided to keep the viscous molten coating from contact with the bare wire. Several refractory base coatings have been considered, among them aluminium phosphate and oxide coatings.

To prevent dielectric breakdown of aluminum oxide coatings at low temperatures resulting from penetration of moisture to the base metal through the pores of the aluminum oxide, a sealing coating is needed. Four types were considered: (1) ceramic-organic coatings; (2) ceramic-organic coatings applied to anodised wire; (3) inorganic sealers for anodised aluminium wire; and (4) wire coatings for a single temperature cycle.

In missiles and rockets there may be a limited need for electrical insulating coatings that would be expended after being used once. Since the missile or rocket would be used only once, the electrical wiring would have to survive only one temperature rise. Work with this type of coating has produced very good results so far. Anodised aluminium wires have been coated with silicone resin and cured at 200 deg. C., the wires, after curing, being fired by raising the temperature in approximately 40 deg. C. increments each hour. A series of wires was removed after each increment, and checked for electrical properties in the range 200-480 deg. C. The flexibility of all the wires was very good, the fired wires being bent around a mandrel twenty-six times the diameter of the wire before any cracks were visible under a 10-power microscope. The wires could be bent around a mandrel sixteen times the diameter of the wire before electrical breakdown occurred in a sodium chloride solution.

The work done up to now indicates definite possibilities for frit silicone resin sealing compositions, and for the use of colloidal silica impregnation as a sealing medium for aluminium oxide coatings. Aluminium-clad copper wire with a barrier layer of silver has also been coated continuously.

Insulation Testing

Tests of electrical insulation in important equipment are made for only one purpose, to determine that the insulation is adequate for the service for which it is intended. Such tests must be non-destructive, and should not break down or impair the insulation.

The current trend is toward the use of higher d.c. test voltages in making dielectric measurements in the field. Such direct voltages can be as searching as the equivalent peak a.c., but the d.c. test is less destructive to sound insulation, and the test equipment required is considerably smaller in size and weight. An important advantage of dielectric testing with direct voltage is found in the possibility of combining the d.c. proof test with leakage measurements which give information about the condition of the insulation at the applied test voltage. The insulation resistance of any one insulating structure is affected by temperature, moisture content, dirt on the surfaces, widespread weakened areas in it due to deterioration by ageing, and small local weak areas due to mechanical damage. The resistance value, measured at one specific direct voltage for a specific time, represents the influence of all these factors at this particular electric stress in the insulation. This resistance value can be interpreted in terms of insulation condition only where resistance values for a normal and satisfactory condition of the insulation of a certain piece of equipment, at a definite temperature and the same test voltage, were established previously; or where, as in maintenance work, records of tests have been kept for a period of time.

If a time-resistance test is made at a specific direct voltage, the polarisation index, which is fairly independent of temperature, can be interpreted in terms of the other factors which affect insulation resistance, without reference to records of previous tests. The polarisation index is the ratio of the resistance measured 10 minutes after test voltage was applied to the equipment to be tested (and held constant over the entire test period) to that measured 1 minute after test voltage was applied.

The magnitude of the polarisation index may be in the order of 5 for clean, dry insulation, but the closer it is to the value "1" the more questionable is the condition of the insulation. Again, this interpretation is based only on conditions at the one particular electric stress in the insulation corresponding to the test voltage.

FOR FURTHER READING:
High Temperature Insulation for Wire—Wright Air Development Center Report.
High Temperature Electrical Insulating Inorganic Coatings on Wire—Wright Air Development Center Report.

NEW IDEAS IN DESIGN

Outstanding products in current manufacture

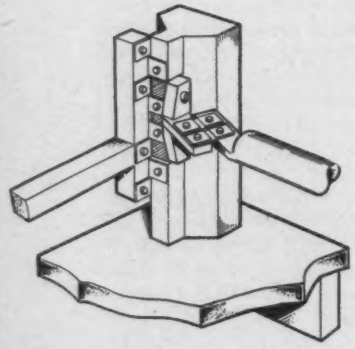
A Step Forward in Microtome Design

FOR cutting extremely thin sections of biological material, for examination under the microscope, the Cambridge Rocking Microtome, an early model of which is illustrated, has been a standard piece of equipment in biological laboratories for many years. The original design, produced by Sir Horace Darwin, F.R.S., in 1885 has, apart from minor points of detail design, styling of the castings and improvements to the cutting blade materials, remained much the same ever since. More recent and indeed contemporary models in the Cambridge Instrument Company's catalogue are very similar in appearance. The basic problem of how to advance the specimen, which is normally embedded in wax, methacrylate resin or other material, towards the knife and then cut the sections by movement of a lever had apparently been solved, at any rate as far as the requirements of the investigator using the ordinary optical microscope were concerned. The arrival of the Ultramicroscope and enormously increased magnifications, however, made it necessary to cut specimens to even less than the 0·025 microns thickness attainable with the rocking microtome.

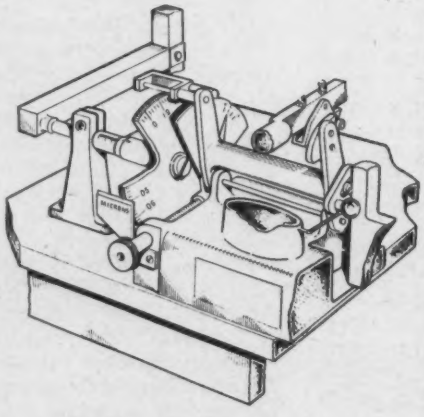
To meet these new requirements the Cambridge Instrument Co. Ltd. have recently introduced the Ultra-Microtome, the prototype of which was developed to the design of Mr. A. F. Huxley, a physiologist, in the Cambridge engineering laboratory. Although at first sight the engineering problems involved do not appear very difficult, closer study reveals that this is not so. The problem of cutting soft materials with consistent accuracy down to 10 mμ (0·000,01 mm.) is a formidable one, particularly when it is decided to employ a straightforward and essentially simple mechanical design. The mechanism must not be susceptible to any wear or play in the critical mechanism for advancing the specimen towards the knife; it must be reasonably immune to vibration and changes in temperature; on the return stroke it is preferable that the specimen should not make contact with the knife blade; operation should not be dependent on skill on the part of the operator, and the microtome should be both rugged and simple.

In the early rocking microtome illustrated it will be seen that increments of advance of the specimen towards the knife blade are brought about by the partial rotation of a serrated wheel by a pawl actuated by the operating lever. This serrated wheel, which is integral with a vertical screw of fine pitch, has the effect of tilting a spring-constrained lever by means of a nut which is free to pivot about its centre, and so accommodates the slight arcuate movement of the lever. On the upper side of the lever, and pivoting about a point immediately above the pivot point of the advancement lever, is a bar to which the specimen is attached. This bar, which is also spring constrained, is operated, by means of a string and pulley arrangement, from the operating lever. In later models, refinements have included the provision of knife edges in place of pivot pins.

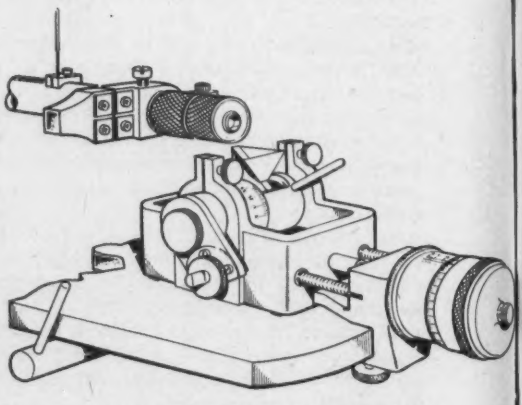
In the Huxley Ultra-Microtome, close inspection reveals that some of the original features have been retained in a rearranged form. Advancement of the specimen is now brought about by a linkage at right angles to the specimen bar and at the end of it rather than near to the specimen collet. The scrap view of the corner post connection shows how this has been done. It will be seen that even knife edges have been avoided, leaf spring connections being used. The specimen bar is advanced once during each return stroke by the short arm of a reducing lever, to which it is hinged by means of a block riding freely between the shoulders of the corner post. The lever is also hinged to the corner post 0·4 mm. to the left of the hinge itself and the block. The lever, which has an arm 100 mm. long, substantially at right angles to the specimen bar, is moved by a ball-ended micrometer screw against which it is constrained by a tension spring. This micrometer screw is advanced by a pawl and ratchet mechanism linked to the movement of the operating arm, which is worked by hand. The amount of automatic advance between the cutting strokes can be pre-set to any distance from zero to 150 mμ by adjusting the calibrated quadrant in front of the toothed wheel. The toothed wheel is also calibrated in fiftieths of a micron and can be turned by hand for cutting sections thicker than 150 mμ, for light microscopy or for quickly moving a known distance through the specimen when cutting sections in a spaced series for



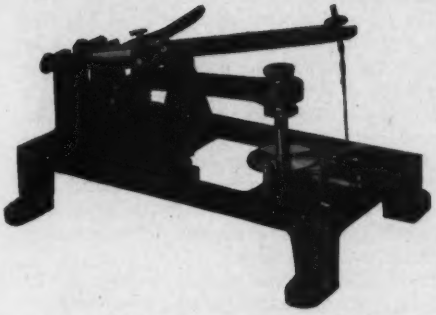
Advance mechanism—corner post connections



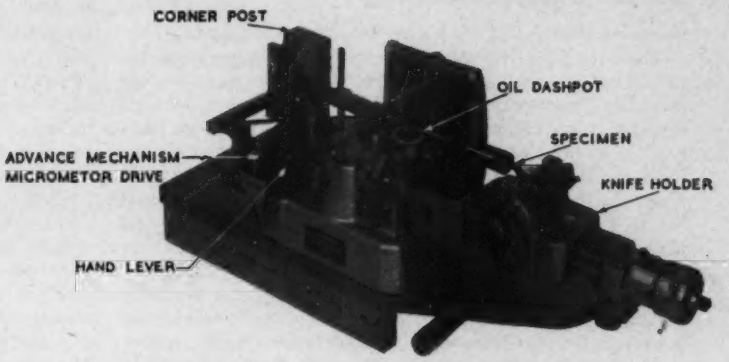
Advance mechanism—micrometer drive



Knife-holder



AN EARLY CAMBRIDGE ROCKING MICROTOME



electron microscopy.

It will be seen that two additional leaf spring connections, in the horizontal plane, connect the specimen bar to the corner hinge block. These springs permit the vertical movement of the bar, while a system of levers linked to a cam, operated by a roller suspended from the operating arm, cause the specimen bar to move to one side and avoid the knife on the return stroke. On the downward stroke the specimen bar falls under its own weight, its speed of fall being controlled by an oil dashpot.

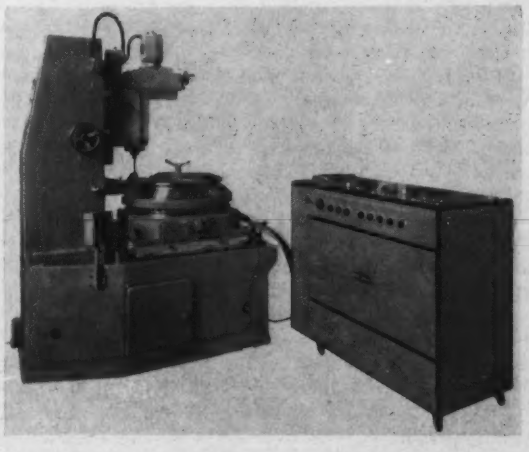
The knife holder is clamped firmly on a movable casting supported by three feet on the base slab in front of the specimen bar. This casting is designed to be easily lifted away from the instrument while the specimen is being mounted, and then replaced exactly in its previous position. The knife holder has two adjustments, one for the degree of knife tilt (calibrated in 3-deg. divisions and reading zero when the front of the knife is vertical), and the other to traverse the knife. This latter adjustment is screw-operated. The position of the casting can also be accurately adjusted in two directions. It can be rotated around a vertical axis passing through the specimen to 20 deg. each side of the centre line of the specimen bar, and it can also be moved along the radius of this rotation towards or away from the specimen by a micrometer screw in 2μ divisions. Any of these four adjustments can be carried out independently of the others. When the adjustments have been made, the whole casting can be locked directly to the base by a clamp which operates without appreciably displacing the knife edge.

The knives used are easily made from plate glass with the aid of a simple 45 deg. cutting jig, a glazier's wheel and two pairs of glazier's pliers. A small metal bath is fitted over the end of the blade to hold water for floating away the sections, and sealed into position to prevent leakage. Diamond tipped knives can also be used for cutting sections of soft metals.

The Huxley Ultra-Microtome is used in conjunction with a binocular microscope and a low-powered light source. A moulded glassfibre cover excludes dust. The only maintenance necessary on this practically wear-free instrument is occasional greasing of the knife holder movements, and oiling of the advancement and displacement mechanisms.

Angular Division to Within 2 Seconds of Arc

FOR the accurate positioning of holes in a circular component, or for various manufacturing operations on gears (including inspection), a number of new techniques for measurement have, in recent years, superseded the old vernier and optical methods. While such methods are no doubt satisfactory for small production quantities, electronic methods with provision for punched tape programming have recently come to the fore. A recent notable development, exhibited at the International Machine Tool Exhibition, is the Sperry/Orcutt dividing engine, which is a rotary dividing table claimed to provide an accuracy of ± 2 seconds of arc, or better. Positions can be repeated to an accuracy of $\pm \frac{1}{4}$ second.



This dividing engine is the result of collaboration between the Gear Grinding Co. Ltd. and the Sperry Gyroscope Co. Ltd., and represents a complete departure from the kinds of technique hitherto adopted to achieve comparable accuracy of indexing. It has a 31 in. dia. platen which will carry loads up to 1,500 lb. Positional control is obtained from information coded onto standard teleprinter paper tape, or from a set of dials mounted on the control console. Positional accuracy is the same for both methods of control, and is said not to be materially affected by changes in temperature or normal fluctuations in mains supply.

The platen of the dividing engine is driven by two electric motors controlled by a servo system. Information for this servo system is obtained from a series of electrical networks situated in the control console. These networks are fed from a large multi-pole synchro fitted to the underside of the platen, and are set up by relays to demand an angle required. The resultant unbalanced voltage in the networks is fed into a servo amplifier to drive the electric motors in such a direction that the changing synchro output will restore the network balance. When this balance is achieved the motors are stopped in accordance with conventional servo theory. The platen, having now reached the desired position, is

automatically locked by a powerful electro magnet.

The base of the dividing engine is of very rigid construction and provides a seating for the work spindle quill assembly, the work spindle itself being mounted on high precision taper roller bearings. The stator of the large slab-type multi-pole synchro is attached to the base, while the rotor is fitted to the underside of the platen. The platen is positively fixed to the top of the work spindle. Also located in the base is the powerful electromagnet for locking the platen. A gearbox, fitted to the underside of the base, carries the two electric motors. Each motor drives, through a separate gear train, the output gear of each train meshing with a common gear mounted on the lower end of the work spindle. As the motors are always torqued to oppose each other, backlash through the gear trains is entirely eliminated. In one of the gear trains suitable pick off gearing is provided to drive a small standard two-pole synchro at the same speed as the work spindle. This small synchro can therefore measure the position of the platen without ambiguity. One side of the base carries the electrical plug and socket panel and an emergency "stop" push-button.

The control console is a metal cabinet mounted on castors for ease of movement. The sloping front carries all the necessary push-buttons and indicator lights, the mode selection switch and the set of dials for positioning. In front of the sloping control panel is a Creed high-speed tape reader and a tape storage box. Behind the control panel are the relays, which are operated from the punched tape or by the dials. Associated with the relays are sets of delta networks incorporating toroid transformers. At the side of the control panel is the transistor servo amplifier mounted on printed circuits. In the base of the console are the power packs and frequency converter, which provide power for the amplifier, servo motors, synchros, relays and external equipment which may be used with the dividing engine.

As the large multi-pole synchro has many positions in which zero error voltages are obtained from the networks, it is necessary to have a standard "coarse" synchro geared 1 : 1 with the platen, in order to guide it to the correct position. The coarse synchro and its associated networks position the platen to within 2 deg. of the demanded position. At this point the multi-pole synchro rigidly fixed to the underside of the platen automatically takes over and brings the platen to its final position.

The fact that the dividing engine can be controlled either by the set of dials or from punched tape enables it to be used both for the production of prototypes and also for making quantities of the same component.

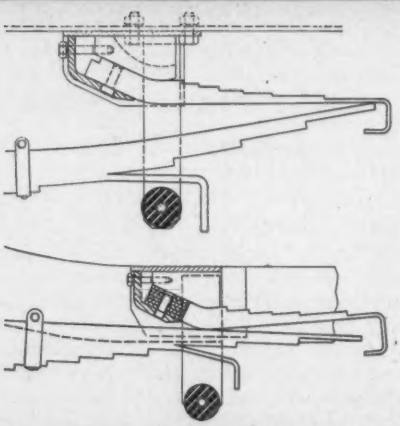
Modified Leaf Spring Permits Wider Load Range

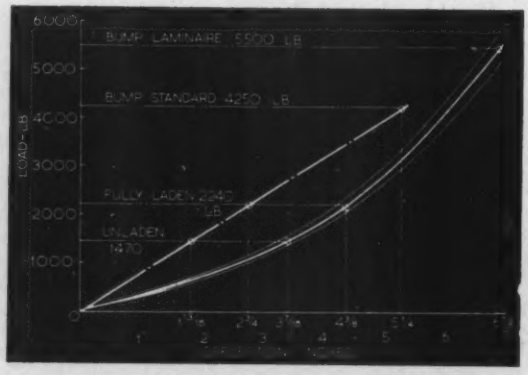
A DISADVANTAGE of the leaf spring for a vehicle which is used for transporting many different kinds of load, both light and heavy, is that it provides a bumpy ride when in the lightly loaded condition. Damage due to spring stiffness can be caused to light but delicate goods, and also to the body and chassis of the vehicle. Moreover, driving the vehicle in the lightly loaded condition can be a tiring operation. Although pneumatic suspension systems, with provision for varying the stiffness of the springing, are making great strides, the majority of vehicles employ the cheaper leaf spring.

The Laminaire system, derived from the springs produced by Heinrich Schomacker, G.m.b.H. of Osnabruck, and recently introduced by William E. Carey Ltd., consists of a modified leaf spring, one end of which is supported by a flexible cantilever leaf spring, the other fixed end being held in a support shoe. The tips only of the two springs are in contact in the unladen position and owing to the flexibility of the cantilever spring a large deflection is obtained, the main spring deflecting but slightly. As the load increases, the main spring makes contact with the cantilever spring at a point progressively nearer to the wheel axle until the cantilever spring is no longer functioning as such, but is only supporting the main spring near to its own point of attachment to the chassis. In this position it will be seen that the main spring is functioning as an ordinary leaf spring.

The problem of rebound, prevalent on a suspension possessing a high flexibility in the unladen condition, has been overcome by the provision of a flexible rubber bush, or roller, in the support shoe. This restricts the downward movement of the main spring. The rubber bush is positioned so that the main and cantilever springs are kept in contact when the suspension is in the free condition, the application of any load causing the main spring to part from the rubber bush.

It is claimed that the weight of material used in the Laminaire is often less than that used in the normal type of suspension. It can be fitted as an alternative to most conventional leaf spring systems.





OVERSEAS NEWSLETTER

A monthly digest of reports from our foreign correspondents of other countries' current achievements in research and development work

Automated Glass Manufacture

A leading example of the mechanisation and automation of plate-glass manufacture is to be found at Glacerie de Chanteraine, in France, where the whole manufacturing process, from the entry of raw materials to the dispatch of the finished plate-glass sections, is supervised by twelve people. The automated part of manufacture involves mixing, cooling and polishing; the processes of examination, cutting, manipulation and fabrication of the glass into specified items are not automated. The storage of raw materials is fully mechanised, the silos being loaded either pneumatically from rail cars or filled by conveyor chains. In the mixing hall, chutes automatically deposit an exact amount of raw material, measured by Swedish electronic weighing machines, on to a conveyor belt.

An electronic "Co-ordinator" desk is supervised by an operator, who sets the desired mixing according to the production programme, each sequence of operations being signalled by lights. The materials thus measured are mixed in rotating drums and transported by a conveyor system to the furnace, which has a capacity of 1,000 tons. Six oil burners are fitted to each side of the furnace, each set operating alternately, thus providing inversion cycles in the direction of heat flow. An elaborate control panel ensures correct burner operation and fully automatic heat cycles. The manufacture of plate glass from the molten material is a continuous, automatic process, the molten glass pouring from the furnace in an uninterrupted stream between two water-cooled rolls located at the furnace outlet to control the glass thickness. The glass, in a semi-fluid state, is supported by driven rollers until it enters the cooling system or annealing lehr. Because the surfaces of the rollers work under temperatures in the region of 1,150 deg. C., vigorous interior cooling is provided.

As the glass, now in a solid state, leaves the rollers it enters a cooling zone consisting of ten separate sections, each section containing electrical heating elements precisely controlled by eight thermocouples, four above the glass and four beneath. Special provision is made for synchronising the speed of the rollers to avoid tension stresses in the glass. After the continuous strip of rough plate glass has left the annealing lehr, it is polished by a twin grinding set, which is to be replaced by a fully automatic system of grinding. The continuous strip is cut to the desired length by a knife travelling on a carriage with the glass strip. After cutting, the glass is lifted by means of vacuum pads and placed on carriers for dispatch.

Measuring Temper Depth

It is reported from Japan that the depth of steel-tempering may be measured by a non-destructive method. Measurement is based on the principle that the magnetic permeability of the steel gradually decreases in the tempered area, and the inductance of an inspection coil placed on the steel varies according to the depth of the temper. It is claimed that by this process the extent of the depth of penetration of tempering can be exactly calculated, independent of the thickness of the metal.

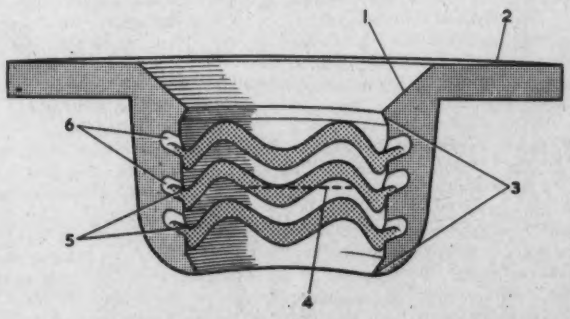
Automobiles of Russia and China

The "Kommunar" plant at Zaporozh'ye is being reconstructed as an assembly plant for the mass production of a new Russian motor car. It is reported that this vehicle is a streamlined four-seater saloon weighing 1,320 lb., with a maximum speed of 50 m.p.h. and a fuel consumption of over 40 m.p.g. The engine is a four-stroke, four-cylinder model with a conventional combustion system and an output of 24 to 27 b.h.p. The use of plastics and synthetic fabrics has been developed for automobile bodies, and at the Likhacheva factory in Moscow an experimental sports car has been fitted with a plastic body possessing the same durability as steel. In the near future the "Moskvich" and "Volga" cars will be produced with plastic bodies.

In the Chinese People's Republic, pioneer work in the production of motor vehicles is being carried out by farm equipment factories, motor vehicle repair shops and electric machine shops. Special emphasis is being given to several types of three-wheeled vehicles with load capacities up to 2 tons. It has also been reported that a 3-ton trailer made of bamboo and wood is in production.

New Shaft Seal

A new plastics sealing element developed in Germany replaces the conventional stuffing boxes, which generally have oil- or grease-impregnated packings requiring regular maintenance. The new seal, known as Permatight, simplifies valve design, and, after installation, requires no maintenance. Sleeve-type sealing lips elastically enclose the rotating part of the valve stem and prevent leakage of the grease from the grease grooves, which undulate circumferentially and are set at an angle to the median axis in the direction of the pressure space. This arrangement is the special feature of the seal, which provides permanent full lubrication and creates a labyrinth packing providing a staged safety system in sealing. The external shape and the elastic property of the plastics material increases the sealing effect even under fluctuating pressures. The funnel-shaped notch in the flange acts as a membrane, and causes the seal to shift axially when pressure fluctuates. The seal is not intended as a rotary shaft seal.



Permatight shaft seal: (1) membrane; (2) flange; (3) sealing lips; (4) overlap; (5) labyrinth packing, and (6) grease grooves.

New Books

Engineering Mathematics. *By J. Blakey and M. Hutton.* (*Blackie & Son—40s.*)

This is basically Dr. Blakey's *University Mathematics*, which first appeared in 1949 as a text for pure and applied science studies. Chapters on polar and general equations of conic and solid geometry have been omitted, and in their stead numerical solution of equations, statistics, relaxation methods and Laplace transforms have been inserted on the grounds that these topics are required by undergraduate engineers. That part of the original book which remains covers the mathematics which is included in all engineering courses; e.g., integration, differentiation, determinants, moments of inertia and differential equations of the first and second order. Partial differential equations are dealt with in three pages.

Today's engineers need a good grasp of all of the topics covered, and the large number of worked and unworked (answers are given) examples from previous examination papers help the reader to achieve this end. However, the present trend in degree courses is towards the inclusion of the Bessel-type equation, matrices, Fourier series, vector analysis and complex variable theory. For better or for worse these topics are being much more freely used by engineers than they were, and there is a strong case for including them in current texts.

This book certainly contains the basic mathematics which is needed, and therefore is a useful addition to the student's booklist.

N. W. Murray

Symposium on Education in Materials. (*American Society for Testing Materials—$2.00.*)

Teaching of materials has become an exceedingly critical and complicated problem, and one for which there is no easy or obvious solution. The purpose of a recent symposium in the U.S.A. on education in materials was to present the views of educators, engineers and industrialists, particularly as applied to the impact of changing environment in the field of engineering materials education.

Hand-book of Stress Relieving and Electrical Pre-heat Application. (*Cooper Electroheat Ltd.—3s.*)

An illustrated hand-book dealing with various methods of applying electrically generated heat to various components and assemblies *in situ*.

Vacuum Processing in Metal Working. *By J. Cable.* (*Reinhold, Chapman & Hall—44s.*)

Vacuum technology is a relatively new field of engineering, and this book encompasses the range of operations found in general metal working. The first part deals with means of producing vacuum, and the latter part covers the various operations, such as deposition, sintering, brazing and welding of metals.

Magnesium and its Alloys. *By C. S. Roberts.* (*John Wiley, Chapman & Hall—72s.*)

This is a presentation of theory and practice relating to magnesium and its alloys. Well illustrated by photographs and diagrams, it will be a useful reference for the physicist, metallurgist and engineer interested in the solid state aspect of materials.

Acrylic Resins. *By M. Horn.* (*Reinhold, Chapman & Hall—36s.*)

This book is of a general nature, and covers four types of acrylics in respect of their manufacture, fabrication and application.

Physical and Engineering Properties of Cast Iron. *By H. T. Angus.* (*British Cast Iron Research Association, 52s. 6d. for members, 73s. 6d. for non-members.*)

This book may be regarded as the design manual for cast iron, and it is to be regretted that similar volumes are not available for other materials. The value of the book lies not only in the information it contains, but in the presentation of the data, the excellency of the photographs and the clarity of diagrams and tables. This arrangement is ideal for the designer, since the nine parts into which it is divided represent in the main the logical considerations in a design problem.

Part 1, "Constitution and Structure of Cast Iron", may be regarded as background information, which, however, should not be ignored. Part 2, "Mechanical and Electrical Properties", is subdivided into chapters, two examples of which are "The Tensile Test" and "The Transverse Test", and enables the reader to understand precisely what is meant by qualified values, a point not always appreciated by both designers and manufacturers. Incidentally, the tables giving comparative strengths and specifications of the U.K. and other countries are extremely useful. Further chapters worthy of note are those dealing with the coefficient of friction and damping capacities of cast iron. Part 3, "General Properties of Cast Iron", covers all types of cast iron. Part 4 thoroughly examines environments such as elevated and sub-zero temperatures, wear and corrosion resistance, machinability and surface finish. Parts 5 and 6 deal with heat treatment and internal casting stresses.

The remaining parts cover specific applications, as, for example, high loadings, beams, columns, pipes and pressure vessels, the final part being entitled "Applications of Specifications and Data to Design". This last section is a little disappointing, but reflecting on the excellency of the preceding data and the method of presentation, it is felt that it may be regarded as superfluous. An Appendix and summarised data conclude one of the most lucid and comprehensive design manuals yet available.

Basic Engineering Metallurgy. *By Carl A. Keyser.* (*MacDonald & Co.—60s.*)

During the present trend towards specialisation in engineering technology, the engineer must take some interest in metallurgy if he is to successfully consider the applications of metals in industry. In this book, the separation of the general engineering metallurgical aspects from those more physical will appeal to engineers who, while pursuing their primary interest, appreciate the additional knowledge of basic engineering metallurgy.

The fundamental theory contains concepts compatible with this book's approach to metallurgy, and also forms an ideal introduction to readers anticipating further metallurgical studies. Modern views on the mechanism of metal behaviour and failure when in service are discussed, together with the primary processes contributing to final applications. Individual metals in related groups cover several chapters, but iron and its alloys are detailed in separate chapters dealing with phase changes and heat treatment.

The author's style is direct and to the point, with many descriptive diagrams essential to a book on this subject. A useful bibliography, and questions, without answers, conclude each chapter.

G. Hills

Data Sheets on Dust Collectors. (British *Steel Castings Research Association —30s.*)

A brochure illustrating the various types of dust collectors, their performance and suppliers.

OTHER BOOKS RECEIVED

Working Aluminium in Shipyards. (*A.D.A. Publication—2s.*)

A.S.T.M. Standards on Light Metals and Alloys. *B.7, fifth edition.* (*A.S.T.M. —$4.50.*)

A.S.T.M. Standards on Electrical Insulating Liquids and Gases (with related information). *D.27, first edition.* (*A.S.T.M.—$4.25.*)

A.S.T.M. Standards on Plastics (with related information). *D.20, eleventh edition.* (*A.S.T.M.—$9.00.*)

Soil Classification for Cable Engineers. *By M. J. Vanner.* (*E.R.A. Publication—10s. 6d.*)

B.S. 3179, Part 1: 1959. *Comparison of British and Overseas Standards for Steels.* (*British Standards Institution —6s.*)

B.S. 3141, Part 1: 1959. *Master schedule of Wrought Steels (Part 1, Carbon Steels).* (*British Standards Institution —10s.*)

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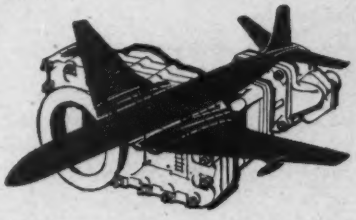

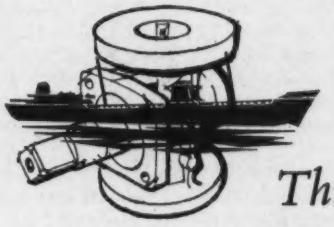

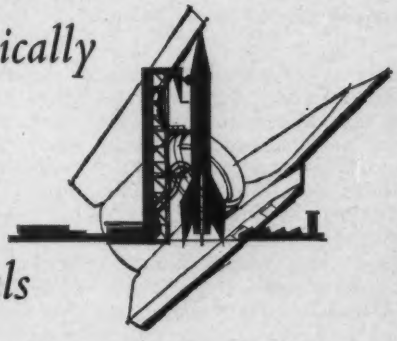

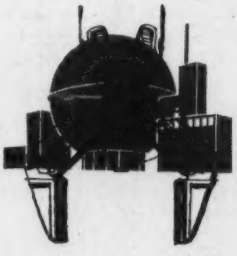

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REVIEW OF DESIGN COURSES

The following courses relevant to engineering design have been announced for the 1960-61 session

DERBYSHIRE

CHESTERFIELD COLLEGE OF TECHNOLOGY, Infirmary Road, Chesterfield. Subject: "Practical Aspects of Welded Design". Two evening lectures, for designers and engineers concerned with fabrication by welding.

DURHAM

SUNDERLAND TECHNICAL COLLEGE, Sunderland. Subject: "Some Aspects of Engineering Design", commencing in October and comprising eight to ten lectures for engineers and draughtsmen.

ESSEX

MID-ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART, Market Road, Chelmsford. Subject: "Design—Art in Relation to Technology". Three years, one evening a week. Intended for qualified engineers, section leaders of design teams and drawing office engineer designers.

HERTS

HATFIELD TECHNICAL COLLEGE, Roe Green, Hatfield. Subjects: "Focus on Design", eight weekly evening lectures commencing in mid-January, 1961; "Design for Manufacture", commencing on January 9, two days a week for eleven weeks. Standard of entry: City and Guilds Machine Shop Engineering or National Certificate.

LANCS

CITY OF LIVERPOOL COLLEGE OF TECHNOLOGY, Byrom Street, Liverpool. Subject: "Design and Stress Analysis". One year full-time, mainly for holders of a Higher National Certificate; they would normally obtain various endorsement subjects and carry out a series of design exercises. Students are mainly "works based".

THE MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY, Manchester 1. Subject: "Machine Tool Technology and Design", two years full-time, commencing in October. Standard of entry: Higher National Certificate in Electrical or Mechanical Engineering. The course leads to the award of a College diploma, and associateship of the College.

PEEL PARK TECHNICAL COLLEGE, Salford, 5. Subject: "Industrial Design," (a) a full-time, and (b) a part-time day and evening course.

Students entering the full-time course (four years) will be expected to have passed the General Certificate of Education at Ordinary Level in mathematics, English language and an appropriate science subject (normally physics or physics-with-chemistry). In addition, students will be expected to pass an entrance examination in art. Age at entry will be 16+ years. The course will lead to an Ordinary National Diploma in Engineering and the College associateship in Industrial Design.

The part-time day and evening course will consist of approximately 125 hours' study over 25 weeks, Tuesday evening and Wednesday afternoon.

There will also be an advanced course of approximately 62½ hours over 25 weeks in one session. A normal requirement for entry to this course will be the satisfactory completion of the above part-time course, or the student will have to show evidence of having achieved a similar standard. The periods of study will be on Thursday afternoon and evening.

LONDON

BATTERSEA COLLEGE OF TECHNOLOGY, Battersea Park Road, S.W.11. Subjects: "Structural Design in Aluminium", six lectures to be held on Monday evenings commencing October 10; "Theory and Design of Circular Cylindrical Shells", eleven lectures to be held on Friday evenings commencing October 7; "Structural Design in Timber", eleven lectures to be held on Friday evenings commencing January 13—post-graduate courses.

BRUNEL COLLEGE OF TECHNOLOGY, Woodlands Avenue, Acton, W.3. Subject: "Some Aspects of Mechanical Engineering Design", November 14-18—full-time course.

COUNCIL OF INDUSTRIAL DESIGN, 28 Haymarket, London, S.W.1. Subject: "Design Appreciation Course for Engineers", for apprentices and junior engineers from both light and heavy engineering industries. The course will be held near London in November and December, and will be arranged in two residential periods, each of four days, separated by an individual study period of three weeks.

THE INSTITUTE OF WELDING, 54 Princes Gate, S.W.7. Subjects: "Design for Welding in General Engineering", November 28 to December 2; "Design for Welding in Thermoplastics", January 30-31. Short full-time courses, intended for senior designers and draughtsmen, with a view to providing them with the latest information about welding and its application.

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, N.1. Subject: "The Engineering Design of Nuclear Power Plant", eighteen evening lectures commencing October 5.

WILLESDEN TECHNICAL COLLEGE, Willesden, N.W.10. Subject: "Press Tool Design", six evening lectures commencing October 19.

NOTTS

NOTTINGHAM AND DISTRICT TECHNICAL COLLEGE, Burton Street, Nottingham. Subject: "Mechanical Engineering Design", post-H.N.C. endorsement, occupying two evenings per week for one year. Although intended for people already holding a Higher National Certificate in Mechanical Engineering, this course is also available for people of equivalent standard, such as engineering graduates.

STAFFS

WOLVERHAMPTON AND STAFFORDSHIRE COLLEGE OF TECHNOLOGY, Wolverhampton. Subject: "Engineering Applications of Plastic Materials", nine evening lectures commencing October 4.

SUFFOLK

IPSWICH CIVIC COLLEGE, Ipswich. Subject: "Engineering Design", thirty evening lectures commencing September 19.

SURREY

KINGSTON TECHNICAL COLLEGE, Kingston. Subjects: "Minimum Weight Structural Design", six evening lectures commencing November 8; "Elementary Compressor Design", twelve evening lectures commencing September 29.

WARKS

COVENTRY LANCHESTER COLLEGE OF TECHNOLOGY, Coventry. Subject: "Practical Aircraft Structural Design", twelve evening lectures commencing September 20.

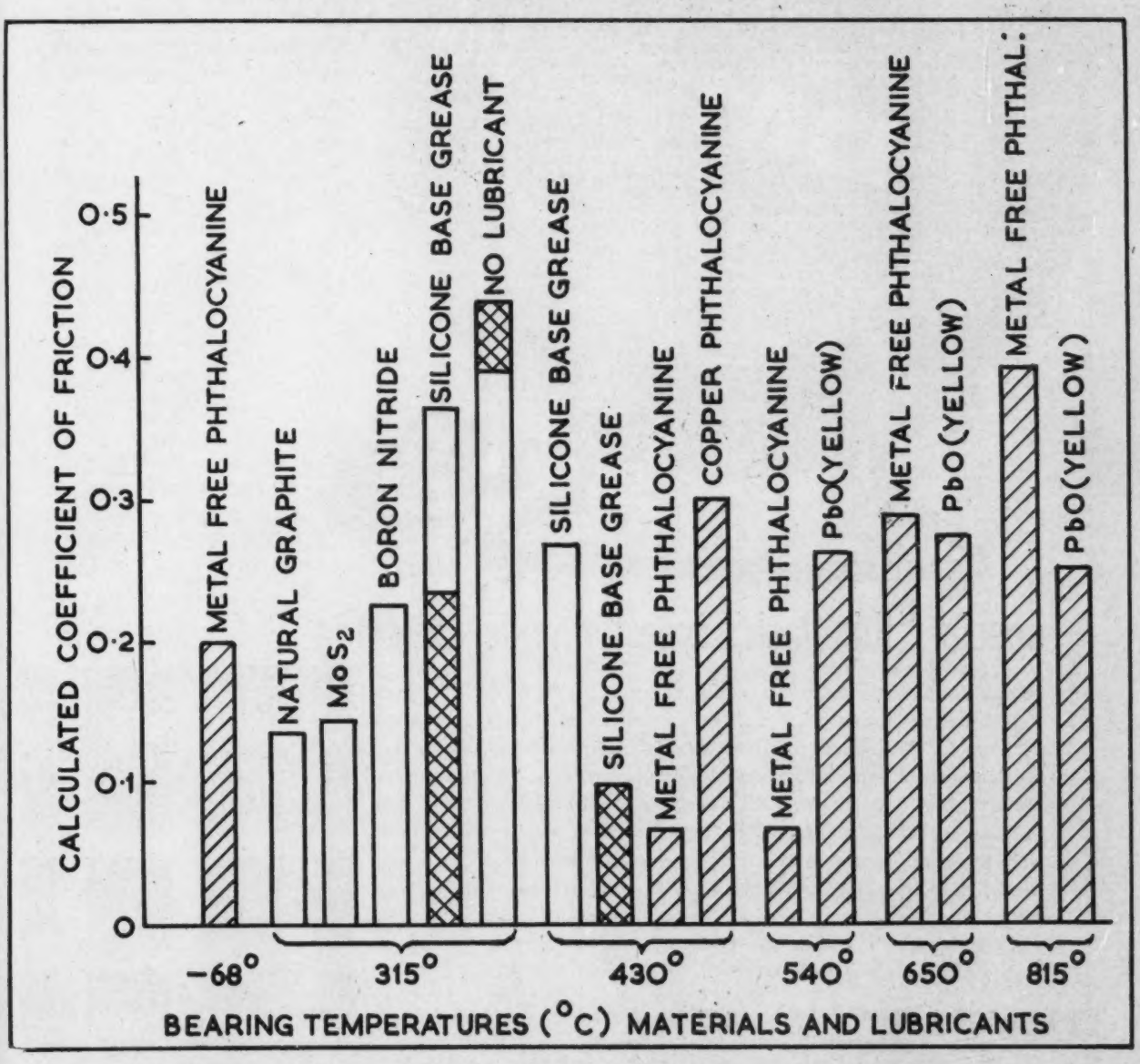
YORKS

CONSTANTINE TECHNICAL COLLEGE, Middlesbrough. Subjects: "The Use of Three-dimensional Models in Design", two or three weekly evening lectures with demonstrations to be given by design engineers from local industry; "The Establishment of Design Stresses", four or five weekly evening lectures to be given by College and visiting staff (students will require knowledge of strength of materials to at least H.N.C. standard); "Design Practice in the Aircraft Industry", six weekly evening lectures to be given by a group of designers from the aircraft industry (students must have at least H.N.C. qualification).

COEFFICIENTS OF FRICTION FOR HIGH-TEMPERATURE BEARINGS

Engineering Materials and Design
DATA SHEET No. 46

The data presented in this chart are from a series of screening evaluations designed to help in the selection of promising materials for use in oscillating high-temperature, heavily loaded journal bearings. The friction coefficient values shown have been calculated from the frictional damping characteristics of a heavily loaded pendulum bearing apparatus used in the screening evaluations. They are intended for comparison purposes only, and should not be taken as absolute values.



Bearing: aluminium bronze. Shaft: 16% Cr, 25% Ni, 6% Mo.

Bearing: aluminium bronze. Shaft: nitrided 16/25/6.

Bearing: heat-treated S-Inconel (68% Ni, 1½% Cu, 11% Fe, 1% Mn, 5½% Si, 15½% Cr, 0·2% C). Shaft: nitrided 16/25/6.

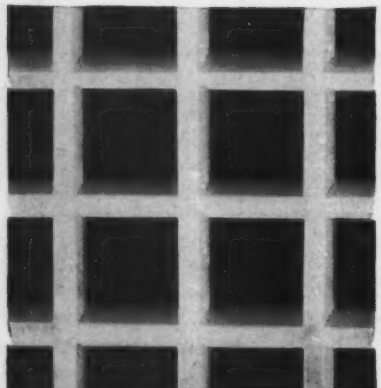
Data by the Battelle Memorial Institute.

for heat resistance

special "thin-flash" type for grille moulding

Beetle D.M.C. is the material used for the grille of the Morphy-Richards Fan Heater because it offers high heat resistance and good appearance. The use of D.M.C. posed a flash-removal problem in relation to the many apertures, as the moulders, Crystalate (Mouldings) Ltd., specified a very thin flash line. Accordingly, B.I.P. Chemicals Ltd. developed a special type of material (D.M.C. L.1834) which, in combination with a tool made to close limits, ensures a consistently thin and easily removed flash.

Beetle D M.C. combines heat resistance with strength, dimensional stability and excellent insulation properties. The development of a special type for a single application typifies the extent of B.I.P. services in relation to individual problems and requirements.



Heat resistance, dimensional stability, strength and electrical insulation properties are among the features making D.M.C. the ideal material for this grille. Moulding by Crystalate (Mouldings) Ltd., Tonbridge, Kent.

BEETLE*

Polyester **d**ough **m**oulding **c**ompound

B.I.P. Chemicals Limited, Oldbury, Birmingham. Phone BROadwell 2061
London Office: Haymarket House, 28 Haymarket, S.W.1. Phone TRAfalgar 3121

ESSHETE 1250

Engineering Materials and Design

DATA SHEET No. 47

This material is an austenitic creep-resisting steel, in bar, sheet and tube form, containing 16% Cr, 10% Ni and 6% Mn, with small additions of Mo, V and Nb. It is weldable, and suitable for continuous service up to 675°C.

Properties (Solution treated at 1,150°C.)

Density at 20 deg. C., 7·94 gm./cc.

Thermal Expansion

Temperature Range (°C.)	*Mean Coefficient (per °C. × 10^6)*
20 -200	16·75
20 - 300	17·65
20 - 400	18·25
20 - 500	18·55
20 - 600	18·95
20 - 700	19·30

Thermal Conductivity (Estimated)

Temperature (°C)	*Thermal Conductivity (c.g.s. units)*
100	0·033
200	0·037
300	0·041
400	0·045
500	0·048
600	0·052
700	0·055

Specific Heat

Temperature Range (°C.)	*Mean Specific Heat (Cal./gm./°C.)*
20 - 200	0·122
20 - 300	0·126
20 - 400	0·128
20 - 500	0·131
20 - 600	0·133
20 - 700	0·135

Electrical Resistance

(*i*) *Resistivity* at 20 deg. C., 74·1 microhm/cm. cube

(*ii*) *Temperature Coefficient*

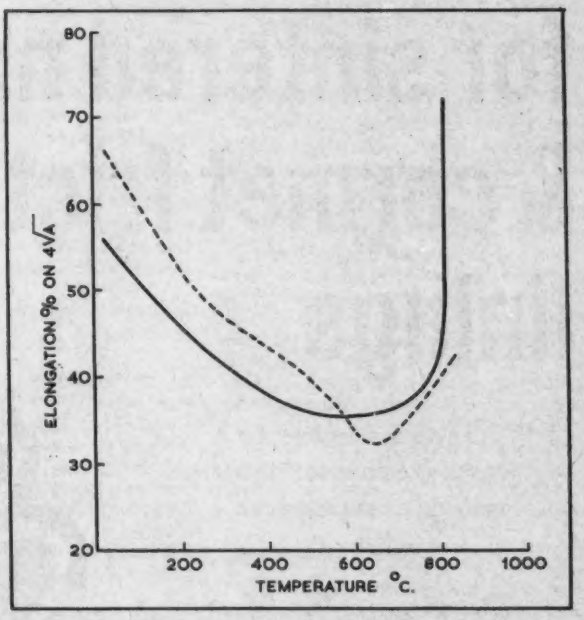
Temperature Range (°C.)	*Mean Coefficient (per °C. × 10^4)*
20 - 100	10·0
20 - 200	9·5
20 - 300	9·5
20 - 400	9·0
20 - 500	8·5
20 - 600	8·0
20 - 700	8·0

Stress (t.s.i.) for Rupture (Average Properties)

Time (hr.)	Test Temperature				
	600°C.	625°C.	650°C.	675°C.	700°C.
100	24·0	20·5	18·0	16·3	15·5
300	22·0	18·5	16·5	15·1	14·6
1,000	20·0	17·0	15·0	13·5	13·0
3,000	18·5	16·0	14·0	12·0	10·0
10,000	16·8	14·5	12·5	10·4	7·5
30,000	(15·0)	(13·3)	(11·4)	(8·9)	(5·8)
100,000	(13·9)	(12·5)	(10·8)	(8·2)	(4·5)

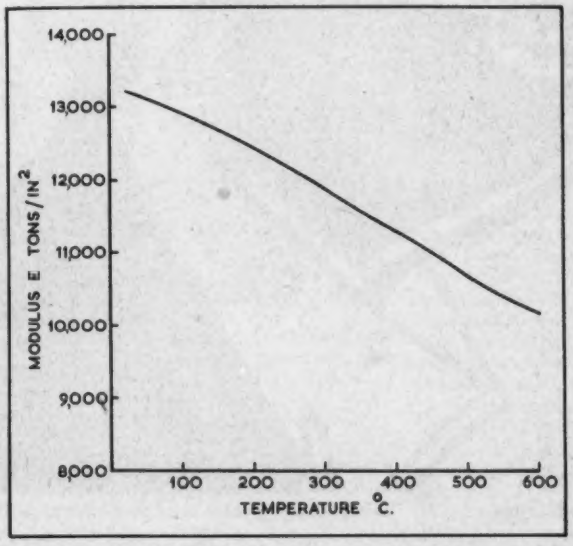
(Extrapolated data are in brackets)

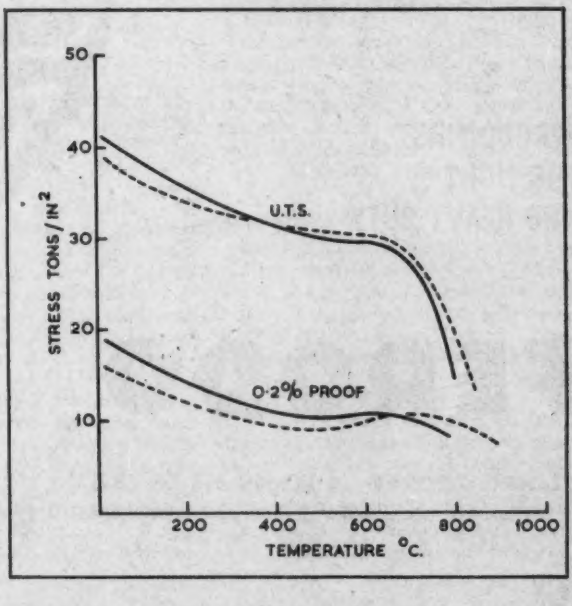
Data by Samuel Fox & Co. Ltd.



SOLUTION TREATED AT 1050° C.

SOLUTION TREATED AT 1150° C.





EMD 3759 for further information

DESIGNERS OF CLUTCH AND POWER TRANSMISSIONS

see Ferodo First for sintered metal & cermet friction linings

when duties beyond the scope of conventional friction materials are called for

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FOR LIGHT
AND HEAVY DUTY

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9/38

What to see at the FACTORY EQUIPMENT EXHIBITION

Skin Cleanser

The Centrex hygienic skin cleanser is claimed to remove not only ordinary grease, oil and factory grime, but also bitumen, tar, paint splashes and even ingrained cast-iron dust and graphite. It is said to be quick, efficient and so safe on the skin that it can be used on any part of the body.

A resin remover known as Centisolve is specially intended for the removal of the synthetic resins now widely used in industry as adhesives. It is claimed to be positive, rapid and completely harmless to the skin. Walkers (Century Oils) Ltd., Century Works, Hanley, Staffs.

EMD 3825 for further information

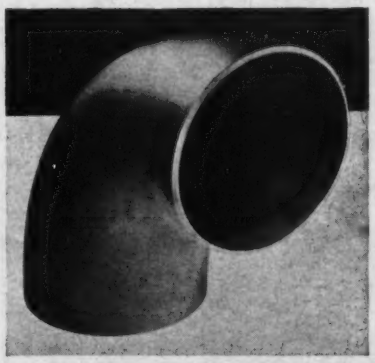
Dry Lubricant

A molybdenised lubricant known as Black-Moly can be applied by a special process to give a dry bonded lubricating coating on metal. Applications range from the treatment of nuts and bolts to plain bearings required to run dry, such as small moving parts on food manufacturing and packing machinery. Particular advantages claimed are the prevention of rust when used under damp or high-temperature conditions, or where used in conjunction with liquids which would wash away a conventional lubricant. John W. Miller & Son Ltd., Hillside Oil Works, Brighouse, Yorks.

EMD 3826 for further information

Stainless Fittings

The Truflo range of fittings is produced in two austenitic stainless steel alloys (304L and 316L), and nickel alloys. Individual fittings are identified with batch numbers so that a full history from



the materials stage is available. Mechanical and weld decay tests are carried out from each batch of material. Wherever possible fittings are seamless, but where they are formed from sheet blanks which are argon-arc welded, the weld bead is normally removed to give a flush smooth finish. All fittings are subjected to hydraulic tests to at least 1½ times design pressure, and individually crack tested. Wilmot Breeden Ltd., 13 Oxford Street, Birmingham 5.

EMD 3827 for further information

Degreaser and Cleanser

A non-toxic hydrocarbon based material known as "101" is recommended for the rapid removal of grease and surface soils from ferrous and non-ferrous metals. It can be followed by painting, plating, anodising, de-rusting or phosphating. The advantages claimed include lower production cost compared to trichlorethylene, non-toxic vapours, no heating or chemical control required and no chemical attack on metals. The plant required can be any suitable tank made of metal, plastic or earthenware other than natural-rubber lined. Period of immersion varies from 1-5 minutes according to degree of contamination but alternatively the solvent may be applied by brush or spray, in which case time factors of a few seconds are said to be adequate. Metal Pre-Treatments Ltd., 240 Clapham Road, London S.W.9.

EMD 3828 for further information

One-coat Finish

A one-coat stone finish known as Colpro can be applied to plaster, concrete, brick work, building boards and asbestos cement sheeting. It may also be used on previously painted wood, metal and corrugated iron. It is claimed that one coat not only decorates but waterproofs, and gives an excellent stone effect in a choice of pastel shades and white. The finish can be applied to damp surfaces, it is said, without fear of subsequent flaking and peeling. Application can be by brush or roller, but it may also be sprayed through a suitable gun. Montgomerie, Stobo & Co. Ltd., Deeside, Saltney, Nr. Chester.

EMD 3829 for further information

Industrial Tapes

A comprehensive range of tapes designed for masking, sealing and protection are exhibited. Contor tapes are used for general-purpose, specialised and high-temperature work including electroplating, sand blasting, shot blasting and dipping. Certain qualities of masking tape perform satisfactorily at temperatures up to 180 deg. C., and others are said to strip cleanly from painted surfaces leaving no residue of adhesive. Cloth, vinyl and polyester tapes are also featured for applications such as stopping off, shock proofing, waterproofing, sealing, cushioning, insulation and corrosion prevention. New products include vinyl protection and polyester silicone tapes with a thermosetting adhesive. John Gosheron & Co. Ltd., The Packaging & Industrial Tape Centre, Albert Embankment, London S.E.11.

EMD 3830 for further information

Fibre Tubing

Sonoairduct is a light-weight fibre tubing primarily intended for warm air ducting. It is claimed to be cheaper to buy and install than metal, clay pipe or concrete ducting. Heat insulation is built in during manufacture, the inside being lined with aluminium foil and the outside wrapped in water-resisting black asphalt kraft. A heat-curing adhesive is used for bonding, to improve the waterproofing and prevent delamination. The tubing is claimed to withstand temperatures up to 135 deg. C. indefinitely, and to have a heat conductivity of 0·46 B.t.u./hour/sq. ft./deg. F./inch of thickness.

A companion product, Sonoairduct-XP, is wrapped on the outside with asbestos—this construction provides increased insulation, which reduces heat loss through the duct wall. The tubing is available in twenty-two sizes, from 2 to 36 in. i.d. in standard lengths of 15 ft. T.P.T. Construction Products, Romiley, Cheshire.

EMD 3831 for further information

Polyurethane Foam

A new rigid polyurethane foam known as Clocel P.E.2. is Freon blown, and claimed to have an excellent low K factor of 0·415 at 78 deg. F., and high compressive strength at a low nominal density of 2 lb./cu. ft. It is available in the form of liquid ingredients for foam-in-situ work, or can be purchased in sheet form under the trade name Spandofoam 200. Clocel can be used on most foam machines, and will be demonstrated on the American Newton foaming machine. The material has good adhesive properties, and when used in moulds it is necessary to use a release agent such as wax polish or polythene sheet. Baxenden Chemical Co. Ltd., Paragon Works, Baxenden, Nr. Accrington, Lancs.

EMD 3832 for further information

Self-cleaning Filter

The Tornado-Fischer automatic self-cleaning filter is shown for the first time. This filter is recommended for cleaning air which contains carborundum dust, cement, chemical products, coal, fertilisers or lime. It is said to need only negligible maintenance, and to function continuously without attention. This feature depends on a special design of filter element embodying a filter fabric and a patented shaking gear. Keith Blackman Ltd., Mill Mead Road, London N.17.

EMD 3833 for further information

Acoustic Tile

The Gyptone acoustic tile is made from acoustic material consisting of mineral fibres bound with a cementitious compound. It is said to be incombustible and thermal insulating, and does not contain ingredients which might encourage mould or fungus growth or prove attractive to vermin. The standard size of tile is 12 in. square, ¾ in. thick, and each tile weighs approximately 1½ lb. The tiles are recommended for applications where sound absorption, fire protection or thermal insulation are required. Gyproc Products Ltd., Singlewell Road, Gravesend, Kent.

EMD 3834 for further information

New Holden advance with

DURUSOL

WATER THINNED STOVED COATINGS

*Based on RESYDROL Resin made by Holdens**

★ *Thin with water.*

★ *Hot Spray, Cold Spray or Dip.*

★ *For Application to Ferrous and Non-Ferrous Metals.*

★ *Optimum Corrosion Resistant Properties.*

★ *No Fire Hazards.*

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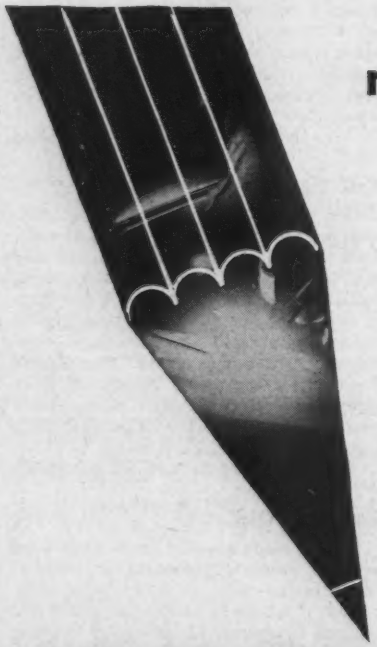
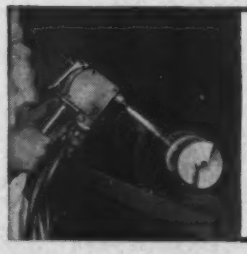


material answer

Sintox—the alumina ceramic of exceptional insulation characteristics, has great mechanical strength, excellent thermal conductivity, and is resistant to corrosive atmospheres, solutions and conditions.
Its characteristics are such that Sintox can be of service in the Electrical, Electronics and Mechanical Engineering Industries and its low neutron capture cross-section makes the material particularly valuable in nuclear applications.

to design problems . . .

Sintox Ceramic Nozzles are employed in the British Oxygen Argon —Arc Welding Process.



Lodge have developed an alumina spraying process giving thermal and erosion protection. Special leaflet on request.

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precision engineering ceramics

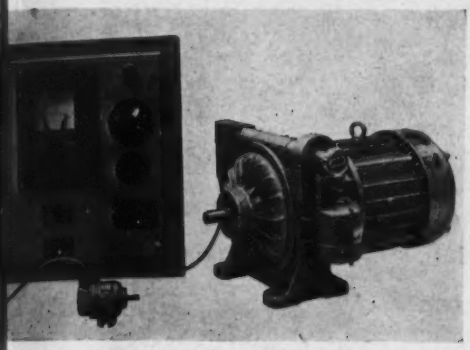
Sintox Technical Advisory Service. Freely available without obligation. Please write for booklet.

LODGE PLUGS LTD., RUGBY, ENGLAND Telephone: Rugby 2076

continued . . .

Variable-speed Drive

The new Speed Corrector Unit is of particular interest to the textile, paper, wire and photographic industries, where problems arise connected with winding. The unit incorporates a Kopp variable-speed gear designed to adjust automatically to a final constant linear or rotary speed. In this way a constant linear speed can be maintained when winding a material on to a drum, to compensate for variations due to build-up of material.



Allspeeds Ltd., Oakenshaw Works, Clayton-le-Moors, P.O. Box 43, Accrington, Lancs.

EMD 3835 for further information

Degreaser and Passivater

A metal cleaner based on phosphoric acid which cleans metal surfaces prior to painting is known as Euron. The manufacturer claims that it will remove oil and grease, destroy rust and oxides, and provide a key for painting by a uniform etching. The surface is also rust inhibited by passivation. The treatment can be applied to iron, steel, aluminium and other non-ferrous metals. The immersion tanks should be of stainless steel, plastic, or mild steel with an acid resistant lining. Roto-Finish Ltd., Mark Road, Hemel Hempstead, Herts.

EMD 3836 for further information

Pipe-cleaning Brush

The new Mole brush, which is completely flexible, is intended for cleaning pipes by normal flow or pressure. When used for pressure cleaning, a large end washer is available. The flexibility of the brush enables it to follow pipe bends, and it can also be used as a fluid or colour changer. The standard range is up to 6 in. dia., but special sizes can be considered. Kleen-E-Ze Brush Co. Ltd., Hanham, Bristol.

EMD 3837 for further information

Power-driven Pallet Rack

A tubular framework of Kee Klamp construction carries horizontal rails of angle iron at each level. Wheeled pallets move along these rails, driven by an endless chain operated by a ¼ h.p. motor which provides power for four levels of pallets, forty-five pallets per level, each of 1 ton capacity. A hook under each pallet engages with a drive block on the chain, and the pallet is moved through the rack at a speed of 4 ft./min. Greater speeds are possible with different gear ratios and a larger motor.

At the leading edge of each pallet a probe projects. This probe, when in contact with another pallet, retracts, thus disengaging the hook from the chain drive. By this method, as the rack becomes full, the pallets come to rest until the leading pallet load is withdrawn, when the complete level of pallets moves forward to its new position. Geo. H. Gascoigne Co. Ltd., Berkeley Avenue, Reading.

EMD 3838 for further information

Flocking Equipment

Electro-static flocking equipment, both stationary and conveyorised, can be adapted to the processing of most types of fabric and materials including nylon and terylene curtain net. It can also be adapted for flocking plastic sheets and vacuum formed articles. Also demonstrated is the Spraytex Miser fibre gun and rayon flock in various colours, deniers and lengths, together with suitable flocking adhesives. Spraytex (Manchester) Ltd., 168 Oxford Road, Manchester 13.

EMD 3839 for further information

Surface Heaters

A wide range of electric surface heaters for chemical process vessels, glass plant

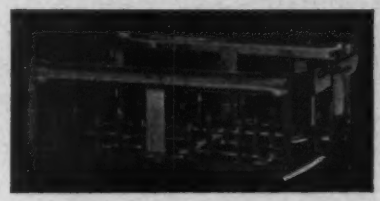
and atomic energy applications is shown, in addition to examples of Isotapes. These are electrical heating tapes for maintaining pipe lines at elevated temperatures.

Isomantles are also available, for pumps, valves, instruments, flow meters and mixers, and an interesting application is for storage bins and drums. There are special designs for flame-proof areas, having a full range of manual and automatic control. Isopad Ltd., Barnet By-pass, Boreham Wood, Herts.

EMD 3840 for further information

Aluminium Trays

These trays, which can be made to any size, are manufactured from high-tensile aluminium alloy which is light, strong and resistant to corrosion. They are primarily intended for handling, storing and transporting textile packages, but have other applications, for instance in hospitals where they are used in sterilisa-



tion of syringes. Thompson Textessories Ltd., St. George's Works, Lancaster.

EMD 3841 for further information

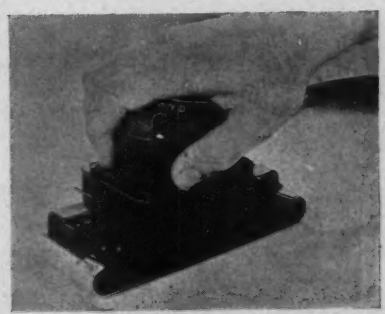
Electrostatic Filter

A new self-contained electro-static filter designed specially for domestic and hospital applications is showing for the first time. The equipment uses Airmaze high-velocity cells in plastic ducting, and is complete with fan and heater. With suitable adaptors it can be floor mounted, wall mounted or suspended from overhead ducts. Also shown is an automatic viscous air filter suitable for varying volumes of air in ventilating systems. The equipment is of a curtain design, self-cleaning and operated normally from compressed air, but where this is either not available or not convenient an electric drive can be arranged. Airmaze oil-wetted and dry-type filters are also shown. Locker Industries Ltd., Warrington, Lancs.

EMD 3842 for further information

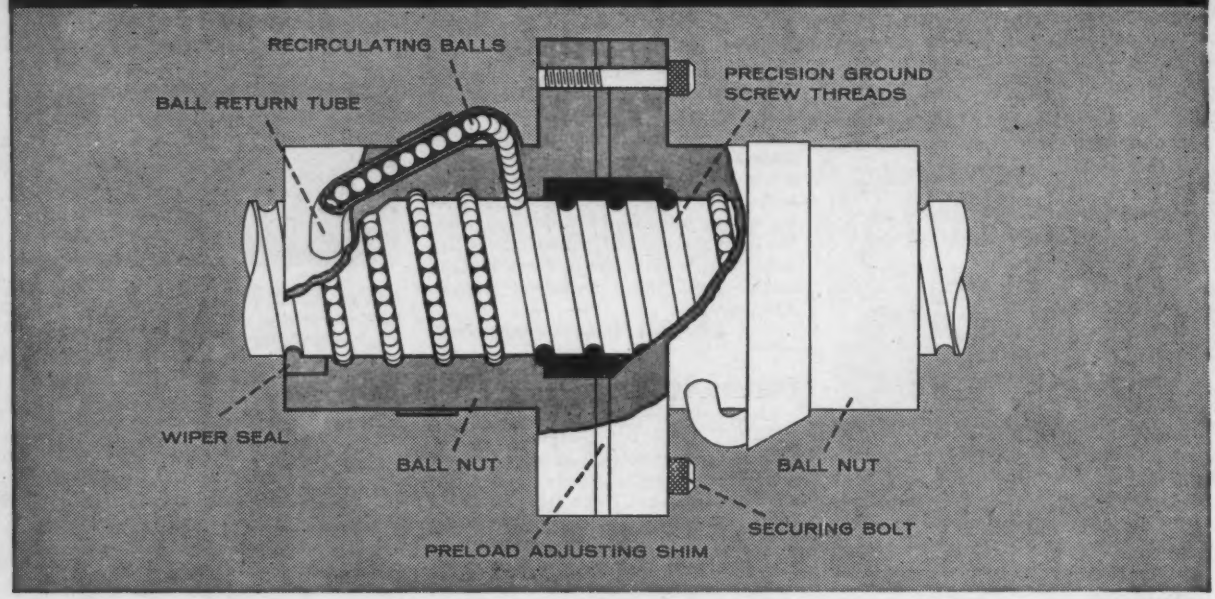
Compressed-air Sander

The model OS-800 Sunstrand compressed-air sander, of single pad orbital design, is shown. This is said to be ideal for restricted areas and vertical surfaces on account of its light weight, lack of vibration and easy handling. Model 1,000 twin-pad (straight-line action), and model OS-700 (single-pad orbital action) sanders are also shown. Shipston Engineering Co. Ltd., Shipston-on-Stour, Warwickshire.



EMD 3843 for further information

Beaver pre-loaded ball screws, up to 95% efficient, operate at -52°C to over 400°C with no backlash...



...ANOTHER ENGINEERING ADVANCE FROM BRISTOL SIDDELEY

Bristol Siddeley Engines Limited produce Beaver* pre-loaded ball screws. These ball screws achieve a minimum efficiency of 90% and they can operate within a temperature range of −52° C to 400° C without lubrication, and up to 170° C when lubricated.

Machined and ground to the highest standards of precision engineering Beaver pre-loaded ball screws greatly increase transmission efficiency. They reduce the power required for actuation by as much as 80%, when converting rotary drive into linear output or force input into torque output. By eliminating backlash, with pre-loading, they give precise control over very small increments of motion and a high response frequency. And when compared to conventional screw mechanisms, they provide a predictable operating life which is much longer, require much less maintenance and give more trouble-free operation.

Basic design application analysis

Bristol Siddeley engineers make an exhaustive analysis of each specification. And each unit is specially designed for its particular application. Beaver ball screws are made automatically reversible or with controlled "no-back," with multiple or single circuits. Beaver pre-loaded ball screws have been proved as the most efficient method of converting rotary into linear thrust in over 2,700 engineering applications in many branches of industry. They have been designed already with rated operating load capacities of 370,000 lb (825,000 lb maximum static load) but the maximum potential operating load is, in most cases, limited only by the requirement.

Bristol Siddeley Beaver ball splines have been developed to eliminate the disadvantages of conventional splines. The designs are very effective in minimising friction, particularly when high torsional and bending loads are imposed during linear movement.

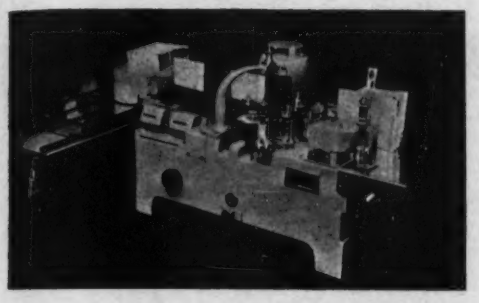
** Complete technical and manufacturing co-operation with Beaver Precision Products Inc., Detroit.*

For further information please write to J. B. Starky, Sales Manager (Beaver Products Division), Bristol Siddeley Engines Limited, PO Box 17, Coventry, England.

BRISTOL SIDDELEY ENGINES LIMITED

continued . . .

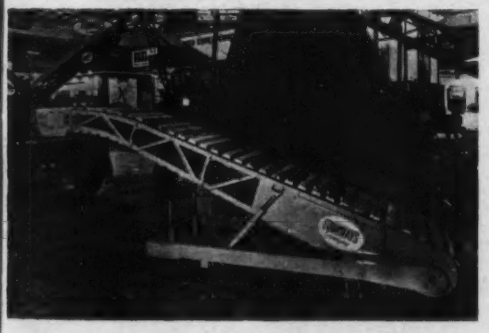
Cancelling Machine



The Klussendorf is a sturdily built machine, suitable for office or factory use, which will automatically handle documents at rates of up to 18,000 per hour, printing on them a cancellation, a date or a serial number. An interesting application is to couple the machine to a micro-filming unit, a date serial number or batch number being applied so that the records on the micro-film can be readily indexed. The machine can be fitted with a settable or non-resettable counter, for use as a counting machine. Halsby & Co. Ltd., 52 Dean Street, London W.1.

EMD 3844 for further information

Swan-neck Conveyor



This is an improved version of the manufacturer's LW conveyor, and is claimed to give greater handling and loading facilities. It is of light construction, highly mobile, has a reversible track, and is suitable for both loading and unloading and for limited stacking. Powered by a 1 h.p. electric motor, it has a unit load of 200 cwt. and a maximum distributed load of 400 cwt. The boom is hydraulically operated. Two models are available, having delivery ranges of 4-8 ft. and 5-10 ft. Fourways (Engineers) Ltd., Hemnall Street, Epping, Essex.

EMD 3845 for further information

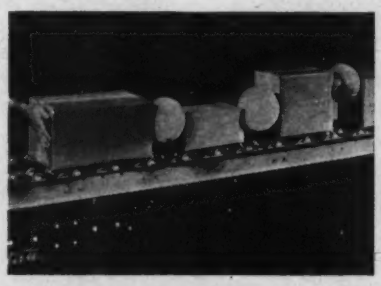
Universal Suction Unit

This unit provides facilities for removing paint-spray mist, dust and health-affecting gas and vapours at any desired working precision. It can also be used as a paint-spray booth or a welding table. A removable dry filter element consists of deflection-type inset filter plates of sheet steel with fine filters behind. The extracted gases are discharged into the open air through flexible hoses of sail cloth or metal. Easy access for cleaning is obtained by pulling the motor and fan out of the unit, and castors are provided to make it completely mobile. H. K. Kunz Ltd., Levenbank Works, Alexandria, Dumbarton, Scotland.

EMD 3846 for further information

Adjustable Pressure Conveyor

Said to be a new development in conveyor design, this equipment is claimed to give positive control of specialised problem areas in a conveyor system. It accumulates cartons under power without



building up line pressure and then releases the accumulated cartons one at a time, automatically spaced for safe movement and if necessary counted. Power requirements are said to be very low, only ¼ h.p. being needed to operate lines up to 200 ft. in length, compared to 5 h.p. for a conventional power belt conveyor. Manufacturers Equipment Co. Ltd., Sutton Road, Hull, East Yorkshire.

EMD 3847 for further information

Oil-free Compressor

A range of oil-free compressors is shown, designed on the diaphragm principle, which eliminates shaft seals, glands and stuffing boxes from the working sections. This is said to avoid the possibility of leakage to atmosphere of the gas being pumped, and the units are therefore very suitable for the circulation of gases in a closed circuit, particularly radioactive gases. Another application is for pumping pure air for breathing purposes. Dawson, McDonald & Dawson Ltd., Compton Works, Ashbourne, Derbyshire.

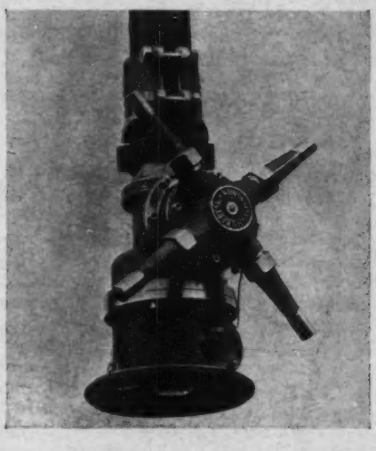
EMD 3848 for further information

Heavy-duty Battery

The new N range of cells is specially designed for heavy-duty applications where the highest possible capacity is required in a limited space. For a given size cell the N range offers an increase in ampere-hour capacity over standard cells, with a much improved capacity:weight ratio. The cells embody pasted positive and negative plates with improved grid alloys and active materials. Triple separation consisting of ribbed Porvic, glass wool sheet and cedar veneers is incorporated, with a patented plate edge insulation to prevent short circuits. The D.P. Battery Co. Ltd., Bakewell, Derbyshire.

EMD 3849 for further information

Turbine Tank Cleaner



A mechanical tank cleaning unit, model H, is driven by a water turbine and discharges hot or cold water with throughputs ranging from 3,000 to 9,000 gall./hr. at 40-150 p.s.i.; detergents may be incorporated when required. The cleaners produce a hydraulic scrubbing action to remove dirt and deposits, and it is said that inaccessible parts of equipment can be cleaned without dismantling. C. P. Equipment Ltd., Mill Green Road, Mitcham, Surrey.

EMD 3850 for further information

Storage Equipment

Fix storage equipment is based on six sizes of self-stacking container, which are semi-open fronted for visibility and accessibility even when stacked. The units are either stove-enamelled or dip-galvanised; the latter are exceedingly strong, will carry a safe load of 5 tons, and are claimed to be rustproof. The four smaller containers are also available in plastics in any of four colours. Kimbell Machine Tools Ltd., 4 South Lambeth Place, Vauxhall, London, S.W.8

EMD 3851 for further information

Blackout Blind

The Sun-dark venetian blind is intended for situations where activities include both normal studies and lantern lectures or scientific demonstrations which require a high degree of blackout. In order to achieve this the blinds have been designed to give ten slats to a foot of drop instead of the usual seven, and the tapes are arranged to obviate any wander in individual slats.

The blind is normally contained in 22-gauge galvanised steel channels at the sides, with a similar channel at the sill. The side channels are fitted with plastic buffer strips to eliminate rattle. Terylene cords are used for maximum strength. J. Avery & Co. Ltd., 81 Great Portland Street, London W.1.

EMD 3852 for further information

Magnesium luggage by Revelation packs ultra-lightness

Excess weight is a drag on arms and pockets. 'Revelation' now join the growing number of manufacturers who kill dead weight the modern way—by using magnesium for their products. Ultra-light magnesium has long been an economical way of reducing weight in components for transport vehicles. Now its outstanding advantages of strength, stiffness and lightness can be exploited in a more 'pedestrian' range of products.

'Revelation' suitcases by W. Wood and Son Ltd.

Magnesium makes the best of ultra-lightness and great strength. Detailed information about properties, performance and uses is always available from MEL—pioneers and sole producers of the metal in Great Britain.

Magnesium Elektron Limited

Clifton Junction Manchester Swinton 2511
London Office: 5 Charles II Street St. James's SW1 Trafalgar 1646
Magnesium Elektron, Inc., New York 20, USA

WHAT'S NEW IN MATERIALS & COMPONENTS

Glass Fibre Mat

To meet the growing demand for specialised glass fibre reinforcement materials, a new emulsion-bound "A" glass mat for contact moulding has been announced and will be available shortly. The chief advantage of the new mat is said to be a considerable reduction in fabricating time which can be achieved without sacrificing quality of the finished laminate.

It is claimed that the dry mat can be handled and tailored without the problem of loose fibres so often associated with chopped strand mat. Excellent drape properties combined with high speed of wetting in resin are said to provide a mat which overcomes many problems of quick and economical moulding. Both "E" and alkali glass mat is available under references ECM.604 and ACM.605 respectively. Turner Brothers Asbestos Co. Ltd., Rochdale, Lancs.

EMD 3853 for further information

Foam Insulation

Thermalon is a stable, rigid carbamide foam having a density of 0·50 lb. per cu. ft. and no structural strength. The weight can be increased for special circumstances. The "K" value is said to be 0·21 B.t.u./sq.ft./hr./deg. F. As might be expected, different ratings are available for the material when used in refrigerated enclosures. The material is said to resist temperatures up to 120 deg. C., to be unaffected by sub-zero temperatures and to be resistant to many solvents. It is claimed that it will not support combustion. The foam can be pressure injected into cavities using special equipment and it then sets rapidly. Thermalon Ltd., 213-223 Lewisham Way, London, S.E.4.

EMD 3854 for further information

Pressure Controller

A recent addition to the Honeywell range of pressure controllers is the new Industrial Pressuretrol, model P428, designed for general applications requiring control or limiting of gas or liquid pressures up to 3,000 p.s.i. It can operate alone as a controller or with other instruments for limit, alarm or signalling service. Five ranges are available, from 30-300 p.s.i. to 300-3,000 p.s.i.

The Industrial Pressuretrol consists of a mercury switch operated by a corrosion-resistant Bourdon tube, enclosed in a heavy steel case which resists dust, weather and corrosion. Pressure setting knobs are conveniently located on the front; tamper-proof knobs can be provided.

An explosion-proof model is available for use in hazardous atmospheres. Honeywell Controls Ltd., Ruislip Road East, Greenford, Middlesex.

EMD 3855 for further information

P.t.f.e.-coated Glass Fibres

Tyglas fabrics and yarns are now being produced in a new range coated with p.t.f.e. Known as Tygaflor, the range covers two types of coated fabric (types A and L), coated yarns for the braided surrounds of wires and cables, and an additional range of yarns for use as sewing threads on heat and chemical resistant fabrics. Type A fabric is recommended for electrical applications as an insulation, or for non-stick surfaces on heat sealing machines, chutes and hoppers. It can also be used as a gasket material and for lining low friction non-lubricated bearings. Type L is similar but is specially treated to increase tear resistance and flexibility, which are of importance in conveyor belting. Tygaflor is said to be capable of withstanding a temperature range from −100 to 250 deg. C. It is of particular interest for the manufacture of endless belts in the chemical and food industry, owing to its inertness and resistance to moisture and chemicals. Fothergill & Harvey Ltd., Harvester House, Peter Street, Manchester, 2.

EMD 3856 for further information

Latex Saturated Paper

A range of natural rubber latex impregnated papers has been developed, primarily for the production of high grade leathercloth. It is possible, however, that this material would be useful in other applications, such as gaskets. It can be obtained in a variety of types of paper, in three standard thicknesses of 10, 20 and 30 mils. The main characteristics are a high edge tear and tensile strength, combined with good stretchability. Development work is in hand to produce a cheaper material of a slightly lower quality, and in various colours. Wiggins Teape & Alex Pirie (Sales) Ltd., Gateway House, 1 Watling Street, London, E.C.4.

EMD 3857 for further information

Tropic-proof Sleeving

A new sleeving, grade VS, has been introduced to type 1, Class 105T, BS 2848/57. It consists of an internal viscose silk reinforcement covered with a plasticised p.v.c. coating. Flexibility is good and the special plasticisers used are said to give good ageing properties for continuous operation up to 105 deg. C. The sleeving is available in eleven colours, with bore diameters of 0·5 to 5·0 mm. The breakdown voltage is claimed to be not less than 3,000 volts. Permanoid Ltd., New Islington, Manchester, 4.

EMD 3858 for further information

Aluminium Plastic Laminate

A sheet material of French origin called Aluthene T. L. H. Barrier is now available in this country. It is made up of three parts: an aluminium foil, a polythene coating on one side, and a paper backing on the other side. This combination of materials provides a sheet having unique properties, for it is flexible, strong and light in weight, and at the same time provides an almost complete barrier to moisture penetration. The material can be welded by heat on account of the polythene layer, a temperature of 160 deg. C. being recommended with light pressure. Claritude Ltd., 19 Dunraven Street, Park Lane, London, W.1.

EMD 3859 for further information

Plastic Glaze

Polytile is a new plastic glaze which can be applied by brushing or spraying to most types of constructional material, such as plaster, cement, wood, hardboard and asbestos board, and also steel. It is claimed to have a remarkably high degree of resistance to humidity, chemicals, solvents, fats and greases, and to be heat resistant up to 200 deg. C. As no stoving is required, it is ideal for finishing products which are too large to heat, and the fact that it is said to withstand cleaning with detergents and disinfectants makes it of particular use in food factories and hospitals. Corrosion Ltd., Southampton, Hampshire.

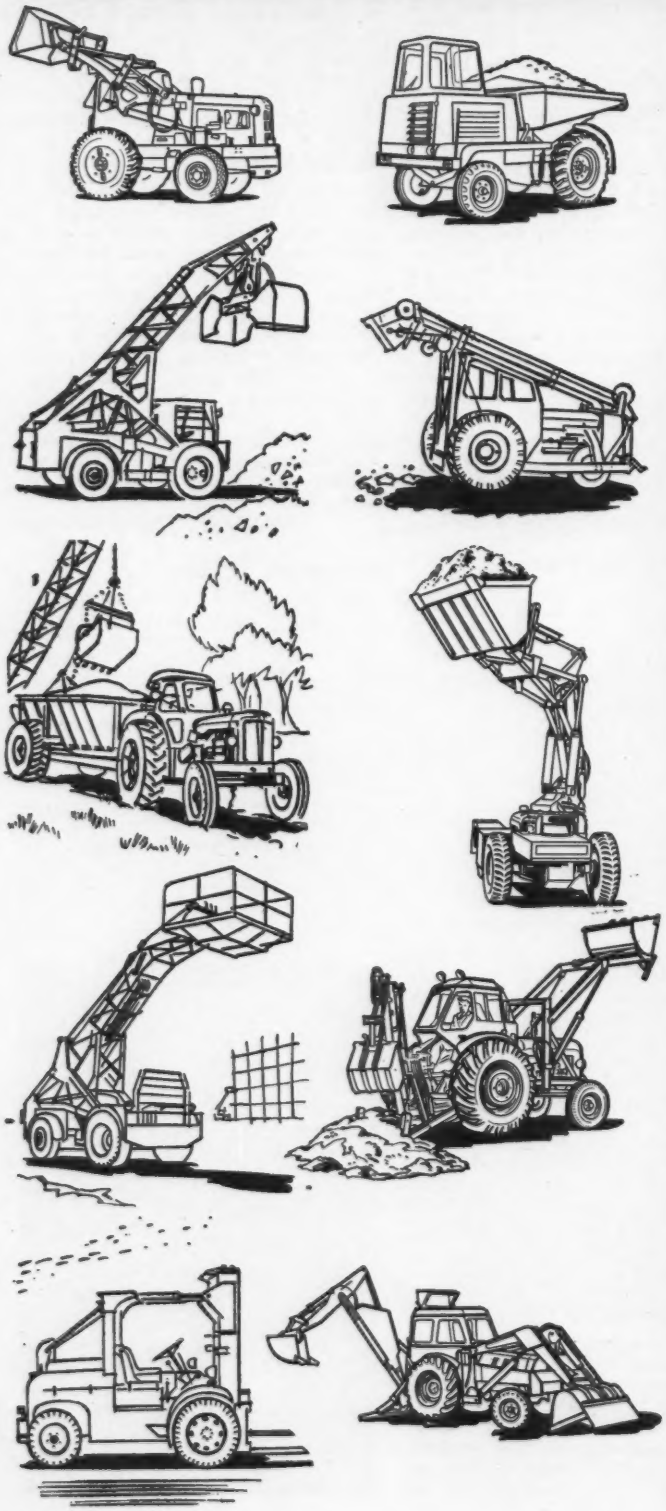
EMD 3860 for further information

Copper-plated Steel Wire

Production has recently started on Copperply (copper-plated steel wire), which combines the strength of steel wire with the electrical conductivity and corrosion resistance of copper. It is produced by a patented spiral plating process, and any desired thickness of copper can be applied up to 40 per cent equivalent conductivity. After plating, the wire is drawn to the required diameter, and it is claimed that the bond is unaffected by drawing, bending, twisting, forming and working. Concentricity of the copper around the steel is held to within 1 per cent of nominal wire diameter. National-Standard Co. Ltd., Kidderminster, Worcestershire.

EMD 3861 for further information

EXPERIENCED OPERATORS INSIST ON



FORDSON POWER

Men who have kept to the tightest schedules in the toughest conditions; men who have manned machines working round the clock, seven days a week; these are the men who know from experience that for proved reliability Fordson Power is unequalled. Add to reliability all the other Fordson advantages of high output, low costs, unrivalled service and spare parts organisation, and almost unlimited choice of build-ups in the 30-40 and 40-50 b.h.p. classes. That's why more Fordson power units than any other are used in industrial equipment. Write for detailed specifications.

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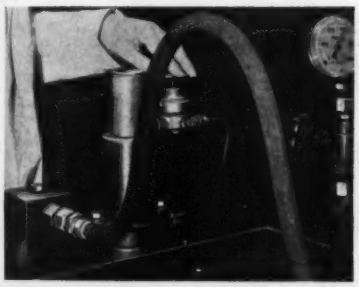
Asbestos Insulation Board

Steel columns and beams may be clad by a newly developed grade of Asbestolux non-combustible asbestos insulation board. This material is ¼ to 1 in. thick and is used in conjunction with cover fillets, which are inserted at cross joints to prevent flame penetration at these points. The screw holes may be filled and rubbed down, leaving the surface ready for immediate decoration after priming. In a recent test a ¼-in. Asbestolux casing protected an 8 × 6 in. steel stanchion under load from collapse for 2 hours. The manufacturers have evolved a range of specifications to give specific degrees of fire protection, ranging from ½ to 4 hours. Cape Building Products Ltd., Cowley Bridge Works, Uxbridge, Middlesex.

EMD 3862 for further information

Flexible Rubber Hose

A new flexible rubber hose, the High-Flex 1104, is of neoprene and flax-braid construction and designed to offer maximum resistance to swelling and ageing. A range of push-in end fittings is supplied, which are said to maintain their hold (as in the age-old Chinese finger trick) without the use of conventional clamps or



clips. The hoses are available in bore sizes up to 1 in, and the one-braid hose will give a working pressure of 300 p.s.i. Crimped end fittings are recommended for use with two-braid hose, thus allowing working pressures up to 800 p.s.i. BTR Industries Ltd., Herga House, Vincent Square, London, S.W.1.

EMD 3863 for further information

Fibreboard Laminate

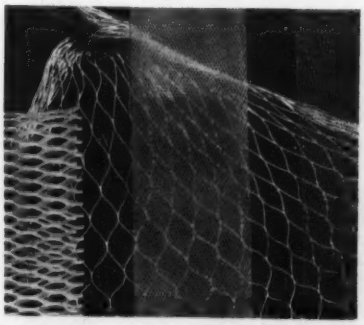
Benelex 70 is a high-density industrial laminate made from cellulose fibres. Supplies are now available in the U.K., in thicknesses from ¼ to 2 in. and in panels up to 12 ft. long. It is a relatively low cost material which can be easily worked, and its main properties are claimed to be high dielectric strength, high tensile and shear strength, and good abrasion resistance (which can be further increased by the application of a suitable chemical hardener). The material is said to have excellent dimensional stability, on account of its low moisture absorption and negligible coefficient of thermal expansion. Mosses & Mitchell Ltd., 60 Ironmonger Row, London, E.C.1.

EMD 3864 for further information

Net-like Plastic Material

A new form of plastics called Netlon is net-like in appearance but neither knotted nor woven. It is made by direct extrusion from a pair of concentric counter-rotating dies, the mono-filaments fusing at the cross-over points before solidification. The end product is an endless tube, which can be cut to sleeves of any desired length, or cut open to form a flat strip.

A wide range of thermoplastics may be used, such as p.v.c., polythene or poly-



propylene. Filament thickness, mesh size, pattern and tube diameter can be varied within wide limits to provide materials of widely differing characteristics, in eight different colours. Netlon is odourless and non-toxic, and is said to withstand indoor or outdoor exposure, and to be resistant to corrosive atmospheres and to most common solvents and chemicals. It can also be produced with excellent electrical insulation properties. Spicers Ltd., 19 New Bridge Street, London, E.C.4.

EMD 3865 for further information

Polycarbonate Sheet

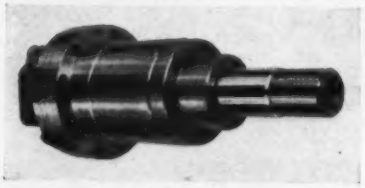
Makrolon polycarbonate sheeting, of German manufacture, is now available in standard thicknesses of 1, 2, 3 and 4 mm. and widths up to 40 in. The chief characteristics claimed for this material are heat resistance up to 135 deg. C., cold resistance down to −100 deg. C., and mechanical strength and rigidity which are practically constant over a wide temperature range. Processing methods which can be used include thermoforming (bending, drawing, blowing and vacuum forming), machining (including buffing and polishing), welding and glueing. Examples of uses include transparent, heat and impact resistant window shields for switchgear; electrical insulation, and heat and acid resistant containers. B. J. Hamlin Ltd., Greener House, 66 Haymarket, London, S.W.1.

EMD 3866 for further information

G. & J. Weir Ltd.: have pointed out that they are responsible only for the manufacture of Clark compressors, not for marketing (see page 517 of the August issue). Enquiries should be addressed to Clark Bros. Co. Division of Dresser (G.B.) Ltd., 197 Knightsbridge, London, S.W.7.

Hydraulic Oscillator

For reciprocating any piece of equipment under a controlled stroke or frequency, a special double-acting cylinder with a stroke of from ¼-2 in. in increments of ¼ in. has been developed. Reciprocation is achieved by means of a built-in, pilot-operated directional valve which supplies



pressurised oil alternately to each side of the piston. The speed of the stroke can be varied from six to sixty strokes per min. By building on a small flow control valve, it is possible to make the speed of the reciprocation independent of load changes. The maximum force available in either direction is 1 ton. The device is strongly made with an integral flange mounting, and is designed for a maximum working pressure of 1,000 p.s.i., with a maximum flow requirement of 1¼ gal./min. for 2-in. strokes at 60 strokes/min. Hydraulic Machinery Drives Ltd., Allesley, Coventry.

EMD 3867 for further information

Conveyor-belt Fastener

A new fastener, by eliminating shallow-slotted nuts and replacing these with high-tensile square-ended screws, is claimed to make for easier fitting and a stronger, more highly compressed joint. The screws are engaged by a turning tool which is provided with an outer sleeve having two lugs at the base. These lugs serve to hold the nut in place while the screw itself is being revolved in an anti-clockwise direction. It is claimed that with this method there is no danger of the tool slipping, and application can be effected with confidence under difficult conditions. The fasteners are said to be compressed into the belt to an extent impossible with the old method, giving a splice of greater strength, and considerably reducing scraper problems. The system is said to be ideally suited for operation with impact tools.

In conjunction with this new application method, a novel fixing jig has been introduced which also acts as a template. By using this jig, all the fasteners required in the making of the splice are pre-set for application to each belt end, with a considerable saving in time. Isaac Jackson & Sons (Fasteners) Ltd., Glossop, Derbyshire.

EMD 3868 for further information

Please Note!

We receive many reader enquiry cards on which the reader has omitted to fill in his name and address. In order to avoid disappointment we remind readers that names and addresses should be included on *each* card.

EMD 3765 for further information

They ought to! They ought to! People who don't protect the inside of their tanks with Ensecote are robbing themselves. Ensecote protective linings will protect practically anything you can put inside a tank, *any* size tank. They're tasteless, odourless, easy-cleaned, sterilized—and economical to apply. Ensecote protective linings add years to a tank's life.

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For literature and technical advice on linings, and on tank fabrication, write to: NEWTON CHAMBERS & CO. LTD., THORNCLIFFE, SHEFFIELD, ENGLAND

Agents in Belgium, France and Holland: FOURS LECOCQ ET ATELIERS DE TRAZEGNIES REUNIS, S.A., TRAZEGNIES, BELGIUM

Balanced Stop Valves

A new range of balanced stop valves is designed for easy operation and complete sealing on high-pressure hydraulic and pneumatic systems. All the valves in the range are completely balanced, and fitted with replaceable nylon seats. They have non-rotating spindles and non-rising handwheels, the operating threads being external to the spindle seals.

The valves can be supplied in mild steel, high-duty bronze and stainless steel, and are available with Ermeto ends for use with nominal bore piping from ¼-1¼ in. dia. They are also available with B.S.P. female end connections from ¼-1¼ in. Special end connections can be effected by the use of stud couplings or stud adaptors with the B.S.P. range. The valves are designed for use in hydraulic systems at a maximum working pressure of 8,000 p.s.i., and on pneumatic systems at a maximum working pressure of 5,000 p.s.i. British Ermeto Corporation Ltd., Maidenhead, Berks.

EMD 3869 for further information

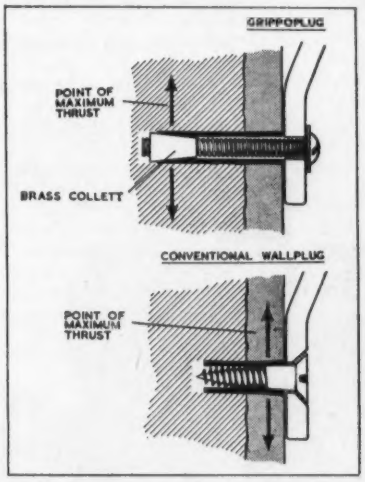
Commercial Bearings

A range of ball bearings designed to reduce production costs and speed assembly is announced. These ball bearings are said to be suitable for all types of non-precision equipment. The range includes many interesting patterns (some of which are illustrated) claimed to be well suited for use in office equipment, conveyor systems, agricultural machinery, washing machines and lawn mowers. One type has the inner ring extended on each side in the form of a collar which is tapped for setscrews so that it can be secured to a shaft. Types with various kinds of dust-proofing seals, and others with grease nipples provided, are included in the range. Bore sizes range from ¼ to 1¼ in. dia., and for any bore size several outside diameters are available. Insley Industrial Supply Co. Ltd., 21/22 Poland Street, London, W.1.

EMD 3870 for further information

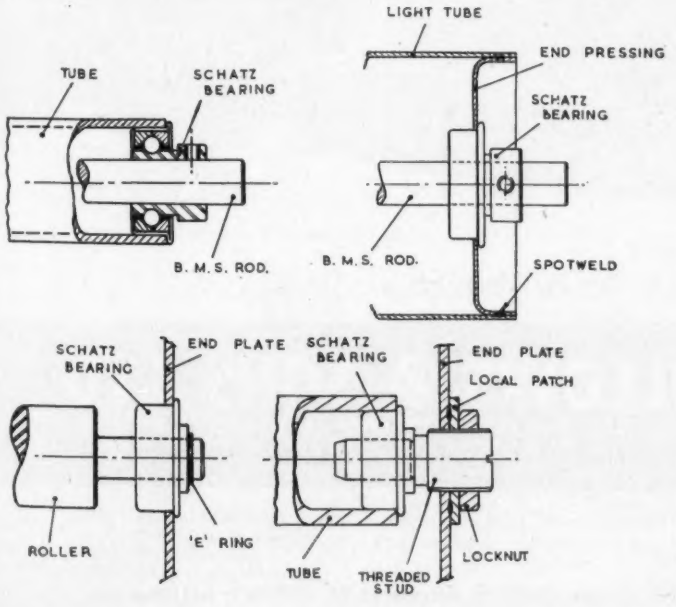
Wallplug

An improved type of wallplug, known as the Grippoplug, has a tapered brass collet which, when fitted, is buried deep inside the wall in an expanding shell, thus securely locking the plug in position with the point of greatest thrust well inside



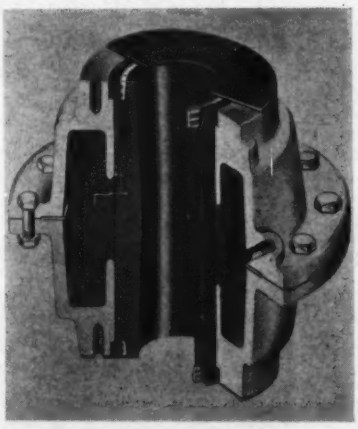
the wall away from the friable plaster. These wallplugs are said to be suitable for fixing wall brackets, shelves, etc., and, in addition, to be suitable for floor fixing of light machinery, benches and other workshop equipment. Grippo Products Ltd., Henshaw Works, Oldham, Lancs.

EMD 3871 for further information



Round Aperture Valve

An improved version of the Sala valve, known as the Type C, is now available. As will be seen from the sectional illustration, this model has a continuous liner throughout the valve, the closure being controlled by pneumatic or hydraulic pressure exerted on the rubber "muscle". The round aperture is infinitely variable from full-bore closure, and the venturi shape of the aperture is claimed to produce very low pressure loss. Aperture is directly proportional to pressure applied, so that the pressure gauge reading gives an exact indication of the valve opening. The



valve is available in sizes from 1 to 4 in. Neldco Processes Ltd., Crossway House, Bracknell, Berks.

EMD 3872 for further information

Decorative Metal Labels

Metal-Cals are identification labels produced by a patented process from 0·003-in.-thick anodised aluminium foil, and held in position by an adhesive film. A protective film is first removed from the adhesive film by immersion in warm water for 40-60 sec.; then, after blotting off surplus moisture, the foil, or cal, is pressed on to the clean dry surface.

Metal-Cals are supplied in various shapes within the limits of 9 × 13 in., or in strip form when additional marking is needed (using a typewriter at stencil position), the units being cut off by scissors or trimmer. Natural or anodised aluminium can be combined with one or more colours: black, blue, red, gold, green, maroon, orange, brown, grey and yellow in glossy or matt finish, or combinations of both. Malby's Metal-Cals Ltd., 1 Queens Park Road, Brighton, 7, Sussex.

EMD 3873 for further information

FOR MORE INFORMATION
about any of the products mentioned on these pages, please use the special reply card bound in this issue.

READERS' ADVISORY SERVICE
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EMD 3766 for further information

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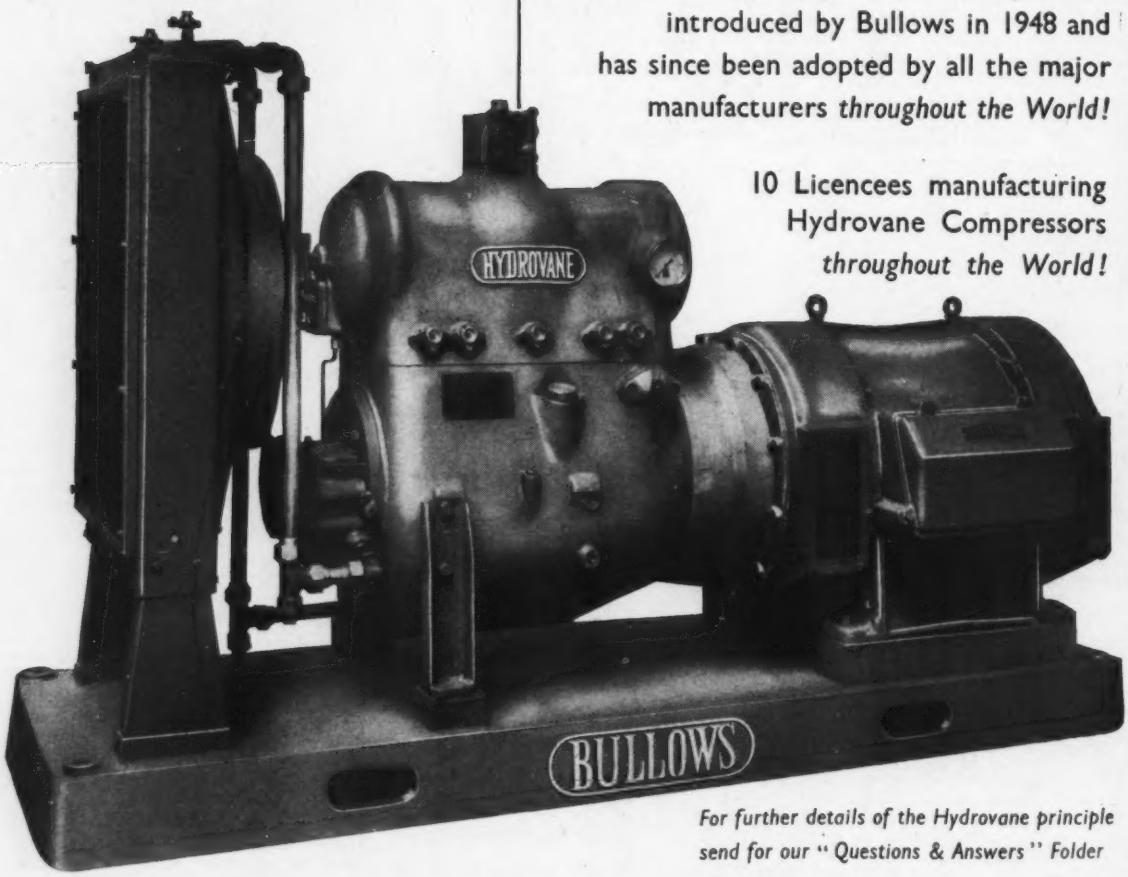
The Hydrovane principle was developed and introduced by Bullows in 1948 and has since been adopted by all the major manufacturers *throughout the World!*

10 Licencees manufacturing Hydrovane Compressors *throughout the World!*



For further details of the Hydrovane principle send for our "Questions & Answers" Folder

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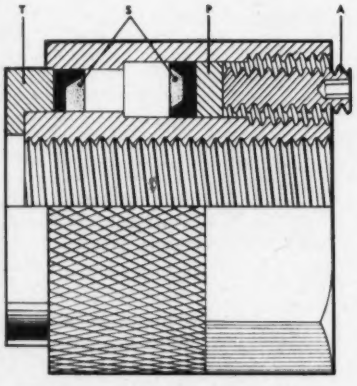
BULLOWS (AUST) PTY. LTD., ETHEL AVENUE, BROOKVALE, SYDNEY, AUSTRALIA.

Hydraulic Nut

The object of the Euco hydraulic nut is to obtain greater pressure with considerably less effort, and at the same time to eliminate the torsional strains which are inevitably present when tightening a nut in the conventional manner. It is claimed that, whereas a 1-in. B.S.F. hydraulic nut screwed on by hand resulted in an initial pressure of only ¼ t.s.i., with the hydraulic pressure applied, by turning the $\frac{5}{16}$-in. pressure screw with an Allen key, the pressure then registered 4 t.s.i.

The body of the nut is made from high-tensile steel, and an annular recess is formed in the front face. This recess communicates with a bore passing through to the rear face, the bore being threaded to receive a reducing bush which accommodates the pressure screw A. The recess and bore are filled with a special compound and enclosed with seals at S. A thrust ring T fits in the recess bearing against the front seal, while a pressure pad P bears against the rear seal and transmits the pressure applied by the screw A.



Euco hydraulic nuts are now available in all sizes from ¼-2 in. dia., and with Whitworth, American, Unified and Metric threads. Special types to provide pressures up to 10 t.s.i. are available to order. Euco Tools Ltd., 44 London Road, Kingston, Surrey.

EMD 3874 for further information

Selector Valves

A range of selector valves, claimed to be ideal for distributing gases or liquids, is announced. These valves are manufactured in a number of types covering from two to six outlet ports. In the case of the four-way valve, distribution can be to any of four outlet ports, while the others remain positively closed, or, alternatively, two ports can open while the other ports remain closed. All the selector valves in the range are normally supplied with a base inlet connector, and each connector is fitted with a patent captive seal union nut. When valves are supplied for less than full selection, the connectors not in use are fitted with blanking caps.

Selection is controlled by the rotation of a cam-shaped spindle which contacts individual valve stems in each distributing connector. The selective operation, said to be unmistakable, is by rotation of the handle, which enables a flat on the spindle to locate opposite the selected connector; a stainless-steel pressure spring then lifts the valve member from its seat.

Types A.3600 and A.3700 have square bodies for panel mounting by two 2 B.A. screws. Type A.1800 has a hexagonal body which is panel mounted by a bracket and two 2 B.A. screws and nuts. The valves are designed in sizes to suit ¼- and ⅜-in. o.d. tubing. Drallim Industries Ltd., Station Works, Westhall Road, Upper Warlingham, Surrey.

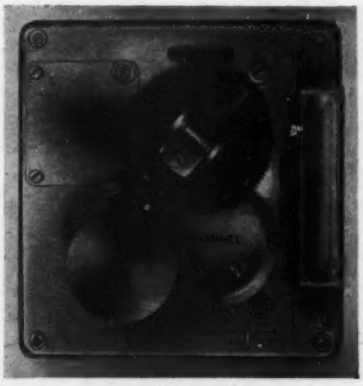
EMD 3875 for further information

Epoxy Encapsulated Motors

The Brook range of British Standard drip-proof motors can now be supplied with epoxy-resin encapsulation of the end windings and slots. Moisture, oil, grit, chemical fumes and the majority of acids and fumes are prevented from entering the windings. The treatment is of particular value in humid conditions. Brook Motors Ltd., Empress Works, Huddersfield. **EMD 3876** for further information

Rotary Position Selector Unit

For situations where it is required to rotate a shaft with a high degree of accuracy, particularly in multi-channel transmitters and receivers, the Plessey remote-control rotary position selector unit is designed to work to an accuracy of 6 min. of arc. It can perform this operation of shaft rotation to any one of twelve positions, each position being set up independently, and is available for 12-48 volt d.c. operation in two panel sizes (4 ×4 in. or 3¼ × 4¼ in.) and with a torque of either 35 oz.-in. or 60 oz.-in.



Visible indication from the front of the unit shows the selected position, and a built-in switch can be used for confirming the position to the remote control site. A further built-in switch allows a number of selector units to be operated in sequence. All materials used in the unit are to Specification DEF 5000. The operational temperature range is from −40 deg. C. to 70 deg. C., and the approximate weight of the unit is 2¼ lb. The Plessey Co. Ltd., Ilford, Essex.

EMD 3877 for further information

New Publications and Technical Literature

Morgan Refractories Ltd.: "Morganite Carbon for the Glass Industry", brochure of data on Tri-mor mouldable, castable refractories. Neston, Wirral, Cheshire.

EMD 3878

Andantex Ltd.: Leaflet describing the Andantex speed reduction unit, which is designed for direct mounting on to the driven shaft of a machine. Tamworth Street, Higher Openshaw, Manchester, 11.

EMD 3879

Mobil Oil Co. Ltd.: Three booklets on the subject of fuel oils: "The Use and Storage of Fuel Oils"; "Steam and Hot-water Boiler Testing"; "Fuel Oil Analysis". Caxton House, Westminster, London, S.W.1.

EMD 3880

Aerograph-DeVilbiss Co. Ltd.: Six-page colour leaflet, presenting in chart form all the facts about heating paint before spraying. 47 Holborn Viaduct, London, E.C.1.

EMD 3881

Wakefield-Dick Industrial Oils Ltd.: "Hydraulic Oils" is a 74-page handbook, with 50 illustrations, with chapters on: the fundamental principles of hydraulics; hydraulic systems, pumps and components; and hydraulic fluids. Castrol House, Marylebone Road, London, N.W.1.

EMD 3882

James Neill & Co (Sheffield) Ltd.: "Users Handbook" of Eclipse permanent magnet chucks and accessories. Napier Street, Sheffield, 11.

EMD 3883

Imperial Chemical Industries Ltd.: Twenty-six page booklet containing data on Butakon A, which are nitrile rubbers having resistance to oils, fuels and solvents. Millbank, London, S.W.1.

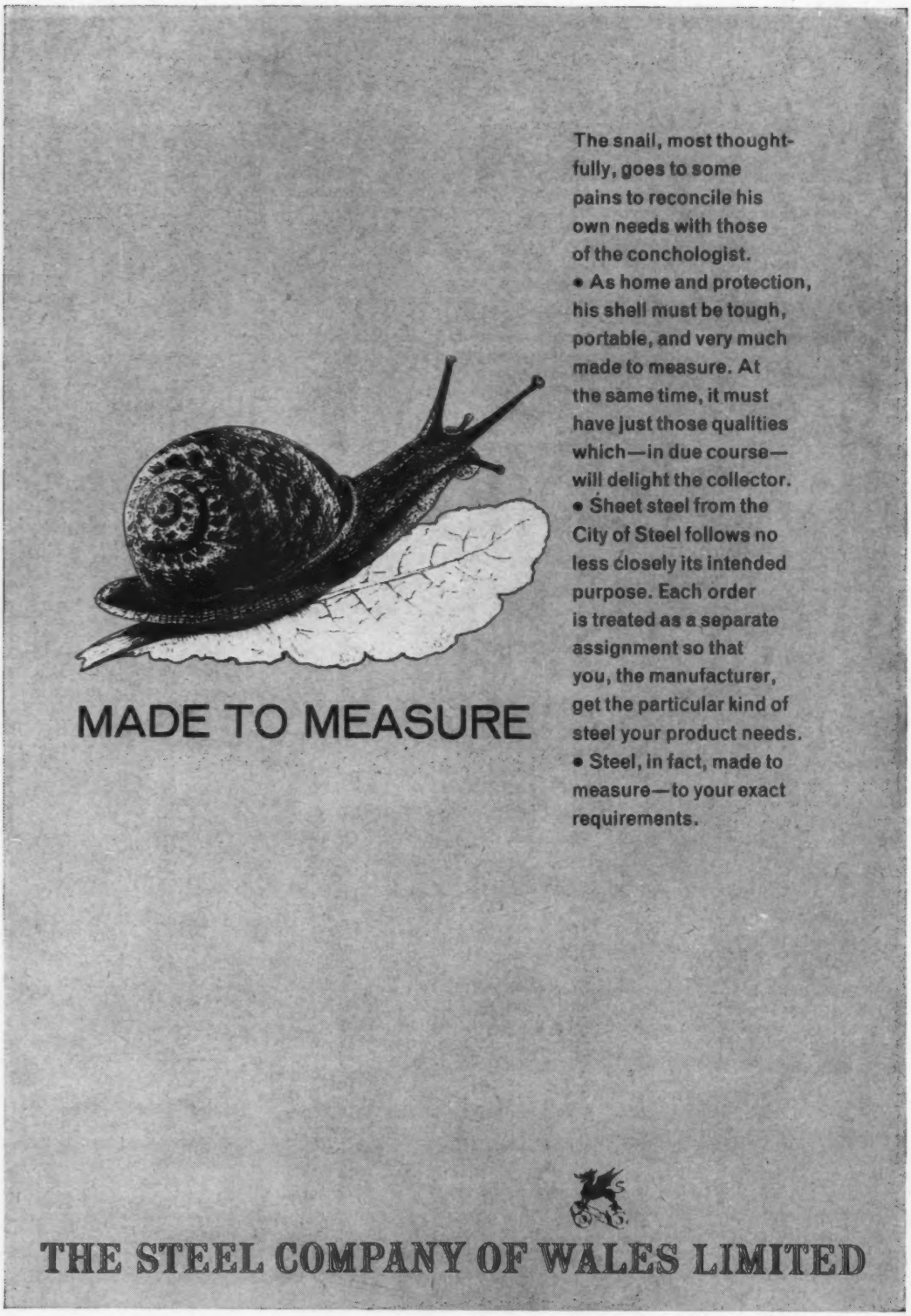
EMD 3884

English Electric Valve Co. Ltd.: "Voltage Stabilisers and Reference Tubes", illustrated booklet containing data and diagrams; "Valve Replacement Index", brochure listing valves, made by various manufacturers, which may be replaced by E.E.V. valves. Chelmsford, Essex.

EMD 3885

CIBA (A.R.L.) Ltd.: Illustrated brochure (20 pages) describing the firm's plastics and adhesive materials. Duxford, Cambridge.

EMD 3886


The snail, most thoughtfully, goes to some pains to reconcile his own needs with those of the conchologist.
• As home and protection, his shell must be tough, portable, and very much made to measure. At the same time, it must have just those qualities which—in due course—will delight the collector.
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News of Industry

Andantex speed reduction units are now manufactured and sold by an independent organisation known as **Andantex Ltd.**, which is directly associated with Société Redex, of Paris, the original inventors.

A new company, **D. A. Stuart Oil Co. (G.B.) Ltd.**, has been formed as a wholly-owned subsidiary of the Amber Group of Companies. This new company has been set up to market in this country metal working lubricants produced by D. A. Stuart Oil Co. Ltd., of Chicago and Toronto.

Winhall & Rogers Ltd., engineering design consultants, engineers' agents and technical representatives, are now at 3 Sherwood Park Road, Sutton, Surrey.

For the first time in this country, complete paint finishing systems, from metal pre-treatment to final stoving, can now be installed by a single organisation, the **Lysaght-DeVilbiss Division** of John Lysaght's Bristol Works Ltd. This organisation has been formed by combining the resources of the two factories.

The new head office of **The United Steel Companies**, at Sheffield, contains many new interesting architectural features. It is believed to be the first building to have windows completely fabricated in stainless steel, and is, in consequence, free from any future external maintenance costs.

The Witton Moulded Insulation Works of The General Electric Co. Ltd. is to be known as **G.E.C. Moulded Plastics Division**. Its products are no longer restricted to the electrical industry, and moulding now carried out there embraces practically the whole range of thermoplastic and thermosetting materials, together with mouldings in bituminous and hard rubber materials.

A new laboratory instructional set is based on the Perkins Mars gas turbine, now being produced at **F. Perkins Ltd.**, and should prove of great educational value for demonstrating the general principles of gas turbines.

Savings of several million pounds per annum are already being made by many branches of British industry through the use of radioisotopes in production and process control. In order to keep industry informed on these materials, and the facilities which they can offer, the U.K.A.E.A. have now opened, at their headquarters in London, an **Isotope Information Bureau**. This consists of an exhibition which will be changed at regular intervals, and a technical expert from the Isotope Research Division, at Wantage, to meet industrialists who feel that their problems could possibly be met by the use of radioisotopes, or who seek guidance in this field.

New hydrofoil patrol craft now being built by the **Boeing Airplane Co.** for the U.S. Navy will have an overall length of 115 ft. and a full load of 110 tons. These craft will be used in coastal anti-submarine operations, and are expected to be completed by 1963.

At the War Office's Proof and Experimental Establishment, at Pendine, is a high-speed track over which test vehicles, running on plain metal bearing surfaces, carry experimental equipment at speeds of up to 4,000 ft./sec. Every inch of the two parallel, precision-made rails is periodically treated with a dry film lubricant made by **Acheson Colloids Ltd.** As no standard equipment was available, a special machine built under contract by **T.T. Works Ltd.**, of Leicester, was constructed to carry out the brushing of the rails, the lubricant being applied by hand. Provided the surface is not damaged, the coating has a fairly good resistance to weathering, a 0·10-in. coating withstanding normal wind and rain for fourteen days. For operational purposes, a coating of a maximum thickness of 0·003 in. is applied, the frequency of application and brushing varying from trial to trial.

Recent improvements in the performance of overhead travelling cranes, such as the introduction of rubber-tyred wheels, have resulted in higher speeds and accelerations. To take full advantage of these increased speeds, it is often necessary to stiffen the mast and provide other stabilising devices. In such cases, slewing motion can be provided by ball bearing slewing rings made by **Roballo Engineering Co. Ltd.** These range up to 120 in. dia., and have teeth machine-cut direct into the bearing ring. Their capacity varies from 1 to 500 tons and they can transmit large tilting moments. No centre pin is required, and masts can therefore be designed to lift or telescope through the centre of the ring, or, alternatively, the centre can be left clear for lifting and positioning such things as large turbine rotors.

Associated Electrical Industries Ltd. and **Davy-United Ltd.** have announced the formation of a jointly-financed Steelworks Automation Unit, to apply new automatic control techniques to the processing of both steel and non-ferrous metals.

New scholarships have been awarded for 1960-61 from the Education Fund of the **Plastics Institute**. They include one two-year scholarship and one four-year sandwich course at the Borough Polytechnic, three four-year sandwich courses at the Birmingham College of Technology, one four-year sandwich course at Brunel College of Technology, and one three-year A.P.I. course at the National College of Rubber Technology.

Allspeeds Ltd., manufacturers of the Kopp variable speed gear, have moved their head office and works recently to Atlas Street, Clayton-le-Moors, near Accrington, where all modern services are incorporated. The machine-shop is laid out and equipped to cater for the latest flowline production methods, thus enabling the present prices to be maintained in spite of rising production costs.

MEETINGS

The Institute of British Photographers has announced that a special three-day conference for industrial staff and cine-photographers will be held at the Central Hall, Westminster, from October 10-12, 1960. A full programme of lectures has been arranged. The conference has been planned with three objects in view: first, to examine new techniques and the latest materials available; secondly to investigate the ways in which photography can be utilised as a tool in industry and commerce; and thirdly, to provide opportunities for discussion on current technical and scientific matters of common interest.

An international conference on quality control will take place at Church House, Westminster, from September 1-3. This meeting is an annual event of the **European Organisation for Quality Control**. Eleven papers are to be presented by leading specialists from Britain, America, Germany, Holland, France, Belgium and Italy, the theme being "Controlling Product Quality—Its Value to Industry".

A vacation course dealing with the transformation of austenite is to be held by the metallurgy department at the **Battersea College of Technology**, from September 27-30, 1960. The course has been designed to demonstrate theoretical advances in this subject of fundamental importance.

The London branch of the **Institute of Metal Finishing** will hold a symposium on nickel and chromium plating on November 16, 1960, at the Festival Hall, London. An exhibition demonstrating proprietary nickel and chromium plating solutions and processes will be included.

The U.K.A.E.A. and the Nuclear Energy Trade Associations' Conference are co-ordinating the British contribution of scientific papers and exhibits to the **Fifth International Instruments and Measurements Conference and Exhibition**, to be held in Stockholm from September 13-16, 1960.

FILMS

Perkins Engines Ltd. have produced, on behalf of Perkins Outboard Motors Ltd., a new colour film called **Channel Crossing**, with commentaries in English, French, German and the Scandinavian languages. Copies of this 13-minute film are available on loan, free of charge.

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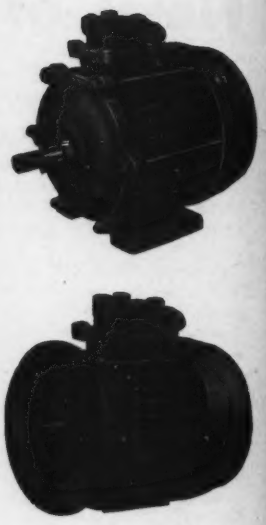

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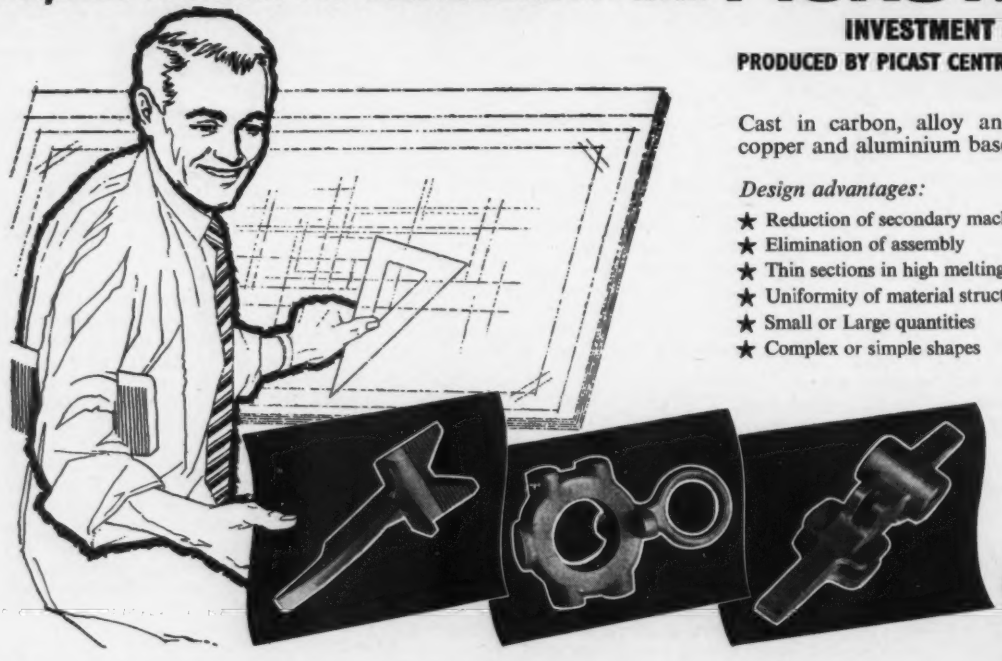

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